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UNIT I

CHEMICAL BASIS OF LIFE

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OAC BIOLOGY

UNIT I

CHEMICAL BASIS OF LIFE

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DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Basic Chemical Concepts
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B011AaSA.01
GUIDELINE OBJECTIVE CODE: 11Aa
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.3, A.9
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: molecular models

Guideline Objective

Students will be encouraged to develop curiosity about the biochemistry of cellular processes.

Item Focus

The student will identify the usefulness of molecular model building to their understanding of biochemical events.

Item

In class, you built molecular models to illustrate aspects of the chemical basis of life. What is the role of model building in the study of biology?

Response/Marking Scheme

Models aid in predicting products of chemical reactions.	1
Models aid in determining the presence of symmetry in molecules.	1
The three-dimensional shape of molecules can be visualized.	1
Geometrical isomers can be visualized.	1
Shapes of functional groups can be visualized.	1
Possible:	5
Maximum:	4

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Basic Chemical Concepts
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B011AbMC.01
GUIDELINE OBJECTIVE CODE: 11Ab
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.9
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: molecular models

Guideline Objective

Students will be encouraged to develop an appreciation for the ways scientific models and theories related to atoms and molecules can be used to assist them to visualize the structure of biological molecules.

Item Focus

The student should be able to identify the usefulness of molecular models.

Item

Which of the following are the reasons molecular models are useful to biologists? Models aid in

I predicting products of chemical reactions.

II determining the presence of symmetry in molecules.

III visualizing the three-dimensional shape of molecules.

IV visualizing geometrical isomers.

V visualizing the shapes of functional groups.

Select your answer from the following:

☐ A. I only

☐ B. I and II only

☐ C. I, II, IV and V only

☐ D. III, IV and V only

☐ E. I, II, III, IV, V

Response/Marking Scheme

Correct response: E

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Molecular Models
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B011AbER.01
GUIDELINE OBJECTIVE CODE: 11Ab Part 1 (3.2-7)
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, E.1, E.3, I.1
DIFFICULTY LEVEL:
TIME ALLOCATION:

KEYWORDS: molecular models chemical concepts

Guideline Objective

Students will be encouraged to develop an appreciation for the ways scientific models and theories related to atoms and molecules can be used to assist them to visualize the structure of biological molecules.

Item Focus

The student should be able to explain the logic behind coherent arguments within science for accepting concepts as plausible in the absence of direct visual evidence.

Item

Individual molecules cannot be seen directly because their size is smaller than the wavelength of light. Yet, scientists speak of molecules as if they actually exist. Outline a logical set of reasons which could be used to justify the existence of molecules.

Response/Marking Scheme

Because molecules cannot be directly seen, the evidence for their existence must be indirect (circumstantial). 1

Chemical and physical phenomena can be explained if it is assumed that matter behaves as if it is composed of discrete particles. 1

Electron micrographs reveal shapes assumed by compounds such as osmium salts which are thought to be attracted to proteins. 1

The shapes are assumed to be those of particles to which the osmium salts adhere. The shapes represent discrete particles (molecules). 1

The laws of thermodynamics are used to account for natural phenomena. 1

The laws make use of the concept that matter is particulate. 1

Phenomena such as solubility and reactivity of substances can be accounted for on the basis of the behaviour of molecules. 1

Physical phenomena such as relative freezing and boiling points of substances can be explained on the basis of particles or molecules. 1

Possible: 8

Maximum: 5

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Basic Chemical Concepts
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B011AbER.02
GUIDELINE OBJECTIVE CODE: 11Ab 11Kh
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, A.9, E.3
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: lock and key model enzyme action

Guideline Objective

The students will be encouraged to develop an appreciation for the ways scientific models and theories related to atoms and molecules can be used to assist them to visualize the structure of biological molecules.

Item Focus

The student should be able to explain the function of a scientific model.

Item

The lock and key model has been useful for representing enzyme activity. However, biologists do not believe that enzymes and their substrates actually look like locks and keys. Explain how the model has been useful to biologists.

Response/Marking Scheme

The model has helped biologists and students visualize a complex abstract idea of enzyme activity	1
in terms ofa common, everyday item.	1
This item, a lock and key mechanism, is familiar and easily understood. It can be used as a metaphor to explain enzyme activity.	1
One critical action of enzymes is the recognition of a particular substrate. A key "recognizes" a particular lock on the basis of fitting of complementary shape. The recognition of a substrate by a particular enzyme is thought to be on the basis of shape.	2
The loss of enzyme activity could be explained by analogy to the lock and key model. If the shape of the key is altered, then its shape will not be compatible with the lock and the key will not open the lock: that is, it will not fit the lock.	2
Similarly, if the shape of an enzyme is altered (by heat or pH changes), the shape of the enzyme is no longer compatable with the shape of the lock, and the enzymatic activity is lost.	2
Possible:	9
Maximum:	6

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B011AbER.03R
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 11Ab Part 1 (8a)
UNIT NUMBER: 01	
UNIT NAME: THE CHEMICAL BASIS OF LIFE	INSTRUMENT TYPE: ER
TOPIC: Basic Chemical Concepts	KLOPFER: A.1, A.2, A.3, E.1, I.1
CURRICULAR EMPHASIS: Nature of Science	DIFFICULTY LEVEL: H
	TIME ALLOCATION:

KEYWORDS: isomers of glucose arguments

Guideline Objective

The students will be encouraged to develop an appreciation for the ways scientific models and theories related to atoms and molecules can be used to assist them to visualize the structure of biological molecules.

Item Focus

The student will develop a logical argument based on scientific concepts to account for two isomers of glucose.

Item

Empirically, we know that glucose is soluble in water. It would be expected that glucose is fairly reactive in aqueous solutions. However, in organisms, glucose is often transported from one area of the organism to another (for example, in animals, glucose is transported by a circulatory system). It would be expected that significant amounts of glucose would react in transit. Empirically, this does not seem to happen. The part of the linear form of glucose which seems to be most reactive is the aldehyde group. If the aldehyde group were inactivated, the reactivity of glucose would decrease.

Suppose that you believed that glucose exists in two forms, one linear and the other cyclical.

Outline a plausible argument that you would use to convince other scientists that glucose can exist in two forms.

Response/Marking Scheme

Through the use of molecular models, it can be shown that the first and fifth carbon of glucose can be joined together through the oxygen on the first carbon, thereby effectively inactivating the aldehyde group.	1
This cyclical form of glucose would be less chemically reactive than the linear form.	1
If the two structural forms were in dynamic equilibrium with each other, with the point of equilibrium shifted towards the cyclical form, then when some of the linear form was used in chemical reactions, the point of equilibrium would shift so as to convert some of the cyclical form into linear form.	2
Since the molecular weights of both cyclical and linear forms are the same, the solubility of both forms should be the same,	1
yet the relative reactivities due to their shape and the presence and absence of the aldehyde group should be different.	1
Possible:	6
Maximum:	5

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Biochemical Research
CURRICULAR EMPHASIS: Science, Technology and Society

INSTRUMENT CODE: B011AdER.01
GUIDELINE OBJECTIVE CODE: 11Ad
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, A.9, I.4
DIFFICULTY LEVEL: H
TIME ALLOCATION:

KEYWORDS: reductionism organismic research medical science

Guideline Objective

The student will be encouraged to develop a realization that biochemistry provides one of several possible approaches to an understanding of living organisms.

Item Focus

The student should be aware of two different views of types of experimentation in biological research.

Item

It can be argued that too much money and time has been committed to the study of the biochemistry of cellular processes to the exclusion of the study of entire organisms. For example, in the medical sciences, the majority of research time and money goes into the study of the biochemistry and molecular biology of cells, the so-called reductionist approach. Those who support the study of the entire organism, the organismic approach, claim that the study of cells in isolation reveals little of how organisms function in the real life situation.

A. State one major assumption on which reductionist research is based.

B. State one major assumption on which organismic research is based.

C. Point out three reasons why reductionist research has been supported by funds to a greater extent than organismic research.

Response/Marking Scheme

A. A major assumption of reductionist research is that the explanations derived to account for phenomena that take place at the cellular level will be applicable to explain life at the organismic level. This is similar to the concept that the whole is equal to the sum of the parts. 3

B. A major assumption of organismic research is that the study of individual parts of an organism introduces a number of factors which are significantly different from the situation that exists in the entire organism. Thus the results obtained from reductionist research probably will not suffice when applied to the entire organism. 3

C.

i. Reductionist research is significantly easier to perform and obtain interpretable results. This is because a single cell or part of a cell is easier to control than an entire multicellular organism, which adjusts and changes in response to each experimental condition. Thus it is more difficult to parcel out cause and effect in organismic research. 3

ii. Many people object to complex organisms such as mammals being used in research. Strict regulations prohibit cruelty to animals. Furthermore, a number of ethical considerations enter the situation when the experimental organism is human. 3

iii. Physiological factors are more stringent in multi- cellular organisms than in single cells. Often single cells are easier to maintain than multicellular organisms which may become ill, die, and invalidate experimental results. 3

Possible: 15

Maximum: 10

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B011AdER.02
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 11Ad
UNIT NUMBER: 01	INSTRUMENT TYPE: ER
UNIT NAME: THE CHEMICAL BASIS OF LIFE	KLOPFER: A.1, A.2, A.3, A.4, I.2
TOPIC: Biochemical Research	DIFFICULTY LEVEL: H
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:

KEYWORDS: investigating phenomena reductionism organismic research

Guideline Objective

The student will be encouraged to develop a realization that biochemistry provides one of several possible approaches to an understanding of living organisms.

Item Focus

The student will explain how two different viewpoints with respect to types of scientific explanations can be held within the scientific community.

Item

Many biochemists believe that biological phenomena can best be explained at the particle level (molecules, atoms, ions). Another view is that biological phenomena can best be explained by studying the entire organisms, not its component parts.

Justify both positions.

Response/Marking Scheme

Reductionist Viewpoint (explanations in terms of particles). The study of an extremely complicated system such as a living organism can be simplified by investigating component parts.	1
By reducing the biological system to much simpler component parts, relatively simple cause-and-effect relationships can be studied.	1
It is hoped that one explanation based on particles can be used to account for all biological phenomena.	1
Experimentation is made considerably easier because in many cases, the experiments can be of the *in vitro* types.	1
Organismic Viewpoint (organism should be studied as an integrated, entire entity).	
Life is more than the sum of component parts.	1
When component parts function in an integrated fashion, other characteristics such as co-ordination and organization become important.	1
These cannot be studied rigorously in reductionist experiments.	1
Issues related to systems within the organism adjusting to changes can only be investigated by studying the entire organism.	1
Possible:	8
Maximum:	6

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B011SaLS.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 11Sa
UNIT NUMBER: 01	INSTRUMENT TYPE: LS
UNIT NAME: CHEMICAL BASIS OF LIFE	KLOPFER: A.2, A.6, A.11, F.1.
	DIFFICULTY LEVEL: M
TOPIC: Biologically Important Molecules	TIME ALLOCATION:
CURRICULAR EMPHASIS: Nature of Science	

KEYWORDS: molecular model amino acid dipeptide condensation lab

Guideline Objective

Students will have the opportunity to develop skill in building molecular models.

Item Focus

The student should be able to develop skill in building molecular models.

Item

Introduction:

You will be permitted 20 min to complete the following model construction. The final model(s) labelled as indicated, will be submitted for evaluation.

Materials: (for each student)

plasticine to represent atoms:
- 16 (white or yellow) representing the element, hydrogen
- 6 (black) representing the element, carbon
- 4 (blue) representing the element, nitrogen
- 6 (red) representing the element, oxygen

72 shortened toothpicks or chenille stems (pipe cleaners)
6 tie-on tags

Method:

Glycine is the simplest amino acid, having a hydrogen atom at the point where the variable portion of the amino acid is normally attached.

1) Construct two molecular models, one of glycine and one other amino acid (electrically neutral / not ionized).
2) Join the two models to form a dipeptide.
3) Write your name on a tag, and use it to identify your work.
4) Use other tags, as many as appropriate, for the following:
   a) identify the product(s) of the reaction
   b) name each functional group on the dipeptide that would be used to incorporate two more amino acids into a growing polypeptide, forming a tetrapeptide.
5) Hand in your completed model(s) along with any unused atoms and bonds.

Response/Marking Scheme

Correct valence used for each element (H=1; C=4; N=3; O=2)	4
NH_2 group attached to α-carbon	1
COOH group attached to α-carbon	1
2 H atoms attached to α-carbon	1
peptide bond correctly formed	1
dipeptide named	1
water included as product	1
water named	1
amino group correctly labelled on dipeptide	1
carboxyl group correctly labelled on dipeptide	1
unused parts returned (2 × C; 4 × O; 6 × H; 2 × N; 52 unused bonds)	1
Possible:	14
Maximum:	14

Teacher Notes

1. It is assumed that students will have worked with commercial model kits prior to this laboratory.

2. Commercial molecular model kits could be used in this test.

3. Plasticine is preferred because it is cheaper and there are no predrilled holes to give clues to normal covalence of the element.

4. The laboratory will require about 20 min.

   Materials: (for each student)

   plasticine to represent atoms:
   - 16 (white or yellow) representing the element, hydrogen
   - 6 (black) representing the element, carbon
   - 4 (blue) representing the element, nitrogen
   - 6 (red) representing the element, oxygen

   72 shortened toothpicks or chenille stems (pipe cleaners)
   6 tie-on tags

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Basic Chemical Concepts
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B011SbLS.01
GUIDELINE OBJECTIVE CODE: 11Sb
INSTRUMENT TYPE: LS
KLOPFER: A.2, A.7, B.4, B.5, C.4.
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: Solutions serial dilution lab

Guideline Objective

Students will have the opportunity to develop skill in making solutions of specific concentrations.

Item Focus

The student should be able to make use of the technique of serial dilution.

Item

Introduction:

You have 20 min to prepare three samples of solutions of the volumes and concentrations indicated starting with the stock solution supplied to you and as much distilled water as you require.
You may use any of the equipment supplied but do not have to use all of it. You will be evaluated on the accuracy with which you attain the required volumes and concentrations.

Materials Available:

4 250 mL beakers (graduated)
1 100 mL graduated cylinder
1 10 mL graduated cylinder
1 10 mL volumetric pipette,
1 10 mL Mohr (serological) pipette
1 100 mL volumetric flask
1 10 mL volumetric flask
3 empty test tubes
1 12 mL sample of 1.0 mol/L Copper II chloride solution (stock solution)
1 balance
safety goggles
1 test tube rack
1 glass-marking pen/pencil
1 pipette filler
(distilled water available in lab)

Safety Precautions:

Do not pipette solutions by mouth! Use the pipette filler supplied.

Method:

1. Label the empty test tubes with your name and the letters, 'A', 'B', and 'C'.

2. Use the stock solution and any equipment you wish to use to place the following into the test tubes (you will be penalized if you have to get more stock solution from the instructor).

TUBE	VOLUME	CONCENTRATION
A	10.0 mL	0.1 mol/L
B	12.0 mL	0.01 mol/L
C	7.3 mL	0.001 mol/L

4. Hand in the tubes for evaluation and return all equipment.

Response/Marking Scheme

Marks may be allotted for each volume within tolerance decided by teacher	6
each concentration within tolerance suitable to instructor	6
equipment returned cleaned	

Possible: 12

Maximum: 12

Teacher Notes

1. Evaluating the degree of success of students can be very time consuming. Using coloured solutions and a set of uniform test tubes can facilitate evaluation. Once the teacher has done the exercise to the desired degree of precision, students' results can be checked quickly using an electronic balance to gauge the accuracy with which volumes have been measured and a colorimeter to gauge the accuracy with which concentrations have been prepared.

2. Surplus equipment should be available to students.

3. The lab should be completed in 20-30 min.

Materials:

distilled water
stock solution (1.0 mol/L copper II chloride (or other coloured solutions)) for each student station:
4 250 mL graduated beakers
1 100 mL graduated cylinder
1 10 mL graduated cylinder
1 10 mL volumetric pipette
1 10 mL Mohr pipette
1 100 mL volumetric flask
1 10 mL volumetric flask
3 test tubes
1 balance
1 test tube rack
1 glass-marking pen/pencil (or adhesive labels)
1 safety pipette filler

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Measuring pH
CURRICULAR EMPHASIS: Practical Applications

INSTRUMENT CODE: B011ScLE.01
GUIDELINE OBJECTIVE CODE: 11Sc 11Se 12c
INSTRUMENT TYPE: LE
KLOPFER: A.1, A.2, A.3, B.1, B.3, D.3, G.2

DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: buffer indicator lab

Guideline Objective

Students will have the opportunity to develop skill in measuring the pH of solutions.

Item Focus

The student should be able to measure the pH of a number of common substances.

Item

In this laboratory exercise, your task is to determine the pH of several common household substances. You will be given a pH indicator and a set of solutions of standard pH to establish the way the indicator works. You will have 20 min to complete the task. Produce an observation table in which to record your results. When you have completed your tests, put your name on the observation table and submit it to your teacher.

Materials:

pH indicator solution
test tubes
distilled water
standard buffer solutions
substances to be tested

Response/Marking Scheme

Experimental technique:

Ensures that test tubes are clean	1
Rinses test tubes with distilled water	1
Establishes colours of standard pH solutions	1
Tests household substances	1
Cleans test tubes after use	1

Results: (1 mark for each correct pH) 7

Substance	pH
lemon juice	2
vinegar	3
sour milk	5
milk	6
baking soda	9
washing soda	10
household ammonia	11

Possible: 12

Maximum: 12

Teacher Notes

1. This mandatory activity should take about 20 min.

2. Students will use a pH indicator to determine the pH of a number of household substances. You may give them fresh Universal indicator solutionm or for the novelty, make an extract by boiling red cabbage in distilled water.

3. Students will calibrate the indicator, using a series of standard buffer solutions.

4. If you are rating student performance, you may choose to have them work alone using different indicators, or different substances. Evaluate technique while the lab is in progress, and then rate the measurements in the tables they submit.

   Materials:

   pH indicator solution
   test tubes
   distilled water
   standard buffer solutions (pH: 3, 5, 7, 9, 11)
   substances to be tested; such as milk, sour milk, lemon juice, vinegar, household ammonia, washing soda, baking soda. You may substitute; saliva, apple juice, cranberry juice, orange juice, etc.

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B011SdLE.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 11Sd 11Kh
UNIT NUMBER: 01	INSTRUMENT TYPE: LE
UNIT NAME: CHEMICAL BASIS OF LIFE	KLOPFER: A.2, A.3, A.7, B.1, B.2, B.3, C.4, D.3, G.1, G.2
TOPIC: Experimenting/Buffers	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:
KEYWORDS: buffer imbibition pH	

Guideline Objective

The student will develop skill in designing and performing experiments to investigate the action of enzymes and factors that affect enzyme activity.

Item Focus

The student should be able to explain the effects of pH changes on the imbibition of water by a protein.

Item

Introduction:

This laboratory exercise requires you to perform a simple experiment, and then interpret the results, criticize the procedure, and attempt to design an improved and extended procedure.

Materials:

powdered gelatin
prepared buffer solutions (pH 4.0, 7.0, and 10.0)
clean white sand
ruler, graduated in mm
graduated cylinder, 10 mL
10 test-tubes, 13 × 100 mL
test-tube rack
safety goggles
grease pencil
timing device (wall clock)
scoopula

Procedure:

1. Carefully measure powdered gelatin into three test-tubes to a depth of 5 mm, and in each case cover the gelatin with a thin layer of sand.

2. Using good laboratory technique, expose the gelatin samples to 10 mL of each of the three buffers for a period of 10 min.

3. Compare, as quantitatively as possible, the volumes occupied by the gelatin after it has imbibed water from the buffer solutions for 6 min.

4. Prepare a short laboratory report, to include your qualitative and quantitative observations (in words or diagrams).

5. Under the heading, Interpretations, draw whatever inferences you feel are warranted about the effect of pH on the abilty of protein to imbibe water. Give an explanation of your observations in terms of the structure of polypeptides and the action of buffers.

6. Under the heading, Criticism, point out three sources of error that might have reduced the value of your results. Also point out any limitations of the experiment that may have prevented you from collecting data from which to form useful generalizations. (Note, however, that increasing the depth of gelatin hinders, rather than helps the experiment.)

7. As an Extension, write a "Purpose" for the experiment. Also indicate three ways you would improve the experiment to overcome the sources of error and limitations you identified in #6.

8. Hand in the test-tubes containing the gelatin to your instructor.

Response/Marking Scheme

Laboratory Technique:

Takes measures to ensure that all tests take equal time.	1
Identifies test-tubes for unequivocal identification.	1
Avoids parallax errors with measuring instruments.	1
Takes care to avoid mixing buffers.	1
Cleaned up: washed glassware, stoppered bottles, nothing missing.	1

Understanding of Theory:

Amino acid residues bear positive and negative charges.	1
Water molecules are polar.	1
At low pH, acid neutralizes negative charges on amino acid residues.	1
At high pH, base neutralizes positive charges.	1

Criticism/Improvement of Experimental Design: (Any 3)

Measurement of powdered gelatin: use flat bottomed shell vials.	2
More accurate to measure mass than volume of gelatin; use a balance.	2
Graduated cylinder inaccurate: use a pipette.	2
Buffers differ in concentration: prepare some with the same.	2
Buffers contain different ions: set up with same ions.	2
Maximum:	15

Teacher Notes

1 Instruct the students as to the amount of time available.

2 The laboratory activity may require 30 min, with another 30 min allowed for the writing of the report. The report could be written in a later class period.

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Denaturation of Protein
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B011SdLE.02
GUIDELINE OBJECTIVE CODE: 11Sd 11Kl
INSTRUMENT TYPE: LE
KLOPFER: A.2, A.3, A.7, B.1, B.2, D.3, G.1, G.2
DIFFICULTY LEVEL: H
TIME ALLOCATION:

KEYWORDS: denaturation lab

Guideline Objective

The student will develop skill in designing and performing experiments to investigate the action of enyzmes and factors that affect enzyme activity.

Item Focus

The student should be able to recognize and account for the phenomenon of protein denaturation.

Item

Introduction:

In this laboratory exercise, you are expected to explain the mechanism of denaturation, based on your observations, and design a new experiment.

Materials:

egg albumen, 1% "solution"
hydrochloric acid, 0.1 mol/L
sodium hydroxide, 0.1 mol/L
ice
10 test-tubes, 13 × 100 mm
test-tube rack
2 beakers, 150 mL
apparatus for heating water
safety goggles
thermometer
5 dropping pipettes
Mohr pipette, 10 mL, with filling device
stoppers for test-tubes
grease pencil

Procedure:

1. Set up five test-tubes, each containing 5 mL of the egg albumen "solution".

2. Place one test-tube into the hot water bath at 60°C, and one into an ice water bath.

3. Keep the remaining tubes at room temperature. To each of these add 5 drops of a different reagent: distilled water to one, hydrochloric acid to the second, and sodium hydroxide to the third. In each case, swirl the tube to mix the reagent with the albumen.

4. Make a record of the changes that occur in each of the test-tubes over a period of 10 min.

Laboratory Report:

1. Record your observations as completely, but concisely as possible. Use whatever format you think is appropriate. Be sure to compare the results in the different tubes.(6 marks)

2. Under the heading, Interpretations, explain your observations in terms of the structure and properties of polypeptides.(4 marks)

3. Under the heading, Extensions, outline a method you might use to determine if any of your observations could be described as "reversible". Attempt any parts of this procedure that you can do with the materials at hand, and report your results.

Response/Marking Scheme

Laboratory Techniques: (4 marks)

test-tubes labelled	1
used safety pipette filler	1
measured volume accurately, avoiding parallax error	1
recorded observations during the experiment	1
Cleaned up well: glassware clean, reagents stoppered, any spilled reagents completely wiped up.	1

Observations: (any 6 marks)

Identifies tube with distilled water as "control"	1
Presents observations effectively	1
Heated tube: heavy "precipitate"	1
large volume, low density "precipitate"	1
Cold tube: no apparent change	1
Acidified tube: albumen seems to dissolve	1
Alkaline tube: similar to acidified, but more so.	1

Interpretations: (any 4 marks)

Amino acid residues electrically charged.	1
Hydrogen ions from acid or hydroxyl ions from base alter charges.	1
As albumen molecules acquire net charge, they repel one another.	1
Heat unfolds the albumen molecules;	1
they refold in a different shape.	1

Extensions: (any 6 marks)

Switch temperature baths of hot and cold tubes.	1
Perform the switch.	1
Observe: no reversal of results in hot tube.	1
"precipitate now forms in former cold tube"	1
Add acid to base tube and vice versa.	1
Perform the experiment.	1
Observe: reversal of results.	1
Suggest need for a centrifuge.	1
Possible:	28
Maximum:	20

Teacher Notes

1. Instruct the students as to the amount of time and marks available. It is suggested that 30 min be allowed for the laboratory activity, and 30 min be allowed for the report.

2. The writing of the report could be done in a second period.

3. A coffee urn makes a good source of the hot water needed, and saves the students' time.

4. Note: the marking scheme requires that you evaluate technique during the lab.

Materials: (for each student)

egg albumen, 1% "solution"
hydrochloric acid, 0.1 mol/L
sodium hydroxide, 0.1 mol/L
ice
10 test-tubes, 13 × 100 mm
test-tube rack
2 beakers, 150 mL
apparatus for heating water
safety goggles
thermometer
5 dropping pipettes
Mohr pipette, 10 mL, with filling device
stoppers for test-tubes
grease pencil

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Atoms
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KaMC.01
GUIDELINE OBJECTIVE CODE: 11Ka
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: atomic number electron proton neutron

Guideline Objective

The student will be expected to explain the meaning of the following chemical terms as they relate to the chemical basis of life: atom, ion, isotope, electronegativity, molecule, isomer, chemical reaction, functional group, polymer, pure substance, mole, acid, base, pH, buffer.

Item Focus

The student should be able to identify information provided on the periodic table about the characteristics of a particular atom.

Item

An examination of the periodic table would reveal the following information about carbon:

6	12.011
	C
	Carbon

From this information, it can be determined that an atom of carbon has the following characteristics:

☐ A. It has an atomic number of 12 and contains 6 protons.

☐ B. It contains 6 neutrons and 4 protons.

☐ C. It has an atomic mass of 12.011μ and possesses 6 electrons.

☐ D. It has 2 protons in the first energy level and 4 protons in the second energy level.

☐ E. It possesses 6 protons, 12 neutrons, and 6 electrons.

Response/Marking Scheme

Correct response: C

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: THE CHEMICAL BASIS OF LIFE
TOPIC: Chemical Bonding
CURRICULAR EMPHASIS: Solid Foundations
KEYWORDS: electronegativity

INSTRUMENT CODE: B011KaMC.02
GUIDELINE OBJECTIVE CODE: 11Ka
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: M
TIME ALLOCATION:

Guideline Objective

The student will be expected to explain the meaning of the following chemical terms as they relate to the chemical basis of life: atom, ion, isotope, electronegativity, molecule, isomer, chemical reaction, functional group, polymer, pure substance, mole, acid, base, pH, buffer.

Item Focus

The student should be able to compare the electronegativity of two atoms, given their atomic masses and electron configurations.

Item

Element A possesses 7 electrons in the outermost energy level of each of its atoms. Atoms of element B also contains 7 electrons in the outermost energy level. However, when neutral, element B has a much lower atomic mass. Therefore,

☐ A. both elements will form covalent bonds more readily than ionic bonds.

☐ B. element A has a lower electronegativity than element B.

☐ C. it is highly probable that these elements will form polar covalent bonds.

☐ D. both elements will tend to give up an electron to become chemically stable.

☐ E. there are insufficient data to draw any conclusive answer from the above.

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Basic Chemical Concepts
CURRICULAR EMPHASIS: Solid Foundations
KEYWORDS: polar

INSTRUMENT CODE: B011KaMC.03
GUIDELINE OBJECTIVE CODE: 11Ka
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

Guideline Objective

The student will be expected to explain the meaning of the following chemical terms as they relate to the chemical basis of life: atom, ion, isotope, electronegativity, molecule, isomer, chemical reaction, functional group, polymer, pure substance, mole, acid, base, pH, buffer.

Item Focus

The student should be able to identify the essential characteristics of a polar molecule.

Item

The essential characteristic of a polar molecule is that it

☐ A. contains the element oxygen.

☐ B. has an asymmetrical distribution of electrical charge.

☐ C. contains ions as part of the structure.

☐ D. is formed at extremely low temperatures.

☐ E. contains double or triple bonds.

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Basic Chemical Concepts
CURRICULAR EMPHASIS: Solid Foundations
KEYWORDS: valence combining capacity

INSTRUMENT CODE: B011KaMC.04
GUIDELINE OBJECTIVE CODE: 11Ka
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

Guideline Objective

The student will be expected to explain the meaning of the following chemical terms as they relate to the chemical basis of life: atom, ion, isotope, electronegativity, molecule, isomer, chemical reaction, functional group, polymer, pure substance, mole, acid, base, pH, buffer.

Item Focus

The student should be able to identify combining capacity as a property of an atom, related to the number of electrons the atom can gain, lose, or share.

Item

The number of electrons that an atom must acquire, lose, or share, to reach a stable outer configuration is called its

- [ ] A. combining capacity (valence).
- [ ] B. electronegativity.
- [ ] C. bond energy.
- [ ] D. isotope.
- [ ] E. mass number.

Response/Marking Scheme

Correct response: A

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Atoms
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KaMC.05
GUIDELINE OBJECTIVE CODE: 11Ka
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: element proton neutron electron

Guideline Objective

The student will be expected to explain the meaning of the following chemical terms as they relate to the chemical basis of life: atom, ion, isotope, electronegativity, molecule, isomer, chemical reaction, functional group, polymer, pure substance, mole, acid, base, pH, buffer.

Item Focus

The student should be able to identify the essential chemical property of all atoms of a particular element.

Item

All the atoms of a given element contain, within their nuclei, the same number of

- [ ] A. protons and neutrons.
- [ ] B. neutrons.
- [ ] C. electrons and neutrons.
- [ ] D. protons.
- [ ] E. electrons and protons.

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Basic Chemical Concepts
CURRICULAR EMPHASIS: Solid Foundations
KEYWORDS: isomer

INSTRUMENT CODE: B011KaMC.06
GUIDELINE OBJECTIVE CODE: 11Ka
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

Guideline Objective

The student will be expected to explain the meaning of the following chemical terms as they relate to the chemical basis of life: atom, ion, isotope, electronegativity, molecule, isomer, chemical reaction, functional group, polymer, pure substance, mole, acid, base, pH, buffer.

Item Focus

The student should be able to identify the concept of an isomer.

Item

Two molecules that are isomers

- ☐ A. must contain the same functional group.
- ☐ B. differ in the number of unsaturated bonds.
- ☐ C. have different molecular masses.
- ☐ D. have the same molecular formula.
- ☐ E. react readily with one another.

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Basic Chemical Concepts
CURRICULAR EMPHASIS: Solid Foundations
KEYWORDS: organic element

INSTRUMENT CODE: B011KaMC.07
GUIDELINE OBJECTIVE CODE: 11Ka
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, D.4
DIFFICULTY LEVEL: L
TIME ALLOCATION:

Guideline Objective

The student will be expected to explain the meaning of the following chemical terms as they relate to the chemical basis of life: atom, ion, isotope, electronegativity, molecule, isomer, chemical reaction, functional group, polymer, pure substance, mole, acid, base, pH, buffer.

Item Focus

The student should be able to identify the chemical elements that occur in organic compounds.

Item

Which element is common to all organic molecules?

- ☐ A. oxygen
- ☐ B. hydrogen
- ☐ C. sulphur
- ☐ D. carbon
- ☐ E. nitrogen

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Basic Chemical Concepts
CURRICULAR EMPHASIS: Solid Foundations
KEYWORDS: isomer

INSTRUMENT CODE: B011KaMC.08
GUIDELINE OBJECTIVE CODE: 11Ka
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

Guideline Objective

The student will be expected to explain the meaning of the following chemical terms as they relate to the chemical basis of life: atom, ion, isotope, electronegativity, molecule, isomer, chemical reaction, functional group, polymer, pure substance, mole, acid, base, pH, buffer.

Item Focus

The student should be able to identify the term optical isomers from a description of the structure of two molecules.

Item

Two organic molecules have exactly the same number and kind of atoms. One of the molecules differs from the other in the spacial arrangements of the same atoms around a particular carbon atom. The molecules are said to be

- [ ] A. structural isomers.
- [ ] B. optical isomers.
- [ ] C. homologous compounds.
- [ ] D. structural isotopes.
- [ ] E. isotonic compounds.

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Basic Chemical Concepts
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KaMC.09
GUIDELINE OBJECTIVE CODE: 11Ka
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: neutron isotope

Guideline Objective

The student will be expected to explain the meaning of the following chemical terms as they relate to the chemical basis of life: atom, ion, isotope, electronegativity, molecule, isomer, chemical reaction, functional group, polymer, pure substance, mole, acid, base, pH, buffer.

Item Focus

The student should be able to identify a pair of isotopes from a description of their structure.

Item

Atoms of a single element which have a different number of neutrons in the nucleus are called

☐ A. isotopes.

☐ B. ions.

☐ C. electronegative atoms.

☐ D. electropositive atoms.

☐ E. isomers.

Response/Marking Scheme

Correct response: A

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Basic Chemical Concepts
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KaMC.10
GUIDELINE OBJECTIVE CODE: 11Ka
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: unsaturated hydrocarbon

Guideline Objective

The student will be expected to explain the meaning of the following chemical terms as they relate to the chemical basis of life: atom, ion, isotope, electronegativity, molecule, isomer, chemical reaction, functional group, polymer, pure substance, mole, acid, base, pH, buffer.

Item Focus

The student should be able to identify an unsaturated hydrocarbon from its structural formula.

Item

Which of the structural formulae shown below represents an unsaturated hydrocarbon?

Response/Marking Scheme

Correct response: A

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Basic Chemical Concepts
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KaMC.11
GUIDELINE OBJECTIVE CODE: 11Ka
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: hydrocarbons functional group

Guideline Objective

The student will be expected to explain the meaning of the following chemical terms as they relate to the chemical basis of life: atom, ion, isotope, electronegativity, molecule, isomer, chemical reaction, functional group, polymer, pure substance, mole, acid, base, pH, buffer.

Item Focus

The student should be able to identify the group of compounds made with carbon-hydrogen bonds.

Item

In which of the following kinds of organic compounds does a carbon atom bond only to hydrogen and other carbon atoms?

- [ ] A. carbohydrates
- [ ] B. nucleic acids
- [ ] C. lipids
- [ ] D. hydrocarbons
- [ ] E. fatty acids

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Functional Groups
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KaMC.12
GUIDELINE OBJECTIVE CODE: 11Ka
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: carboxyl group

Guideline Objective

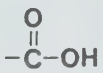
The student will be expected to explain the meaning of the following chemical terms as they relate to the chemical basis of life: atom, ion, isotope, electronegativity, molecule, isomer, chemical reaction, functional group, polymer, pure substance, mole, acid, base, pH, buffer.

Item Focus

The student should be able to identify a drawing of a structural formula of an important functional group.

Item

What functional group is represented by the following structural formula?



- [ ] A. amino
- [ ] B. carboxyl
- [ ] C. carbonyl
- [ ] D. hydroxyl
- [ ] E. sulphydryl

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Functional Groups
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KaMC.13
GUIDELINE OBJECTIVE CODE: 11Ka
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: amino group

Guideline Objective

The student will be expected to explain the meaning of the following chemical terms as they relate to the chemical basis of life: atom, ion, isotope, electronegativity, molecule, isomer, chemical reaction, functional group, polymer, pure substance, mole, acid, base, pH, buffer.

Item Focus

The student should be able to identify a diagram representing the structural formula of a functional group.

Item

What functional group is represented by following the structural formula?

- [ ] A. amino
- [ ] B. carbonyl
- [ ] C. carboxyl
- [ ] D. hydroxyl
- [ ] E. sulphydryl

Response/Marking Scheme

Correct response: A

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Functional Groups
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KaMC.14
GUIDELINE OBJECTIVE CODE: 11Ka
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2. A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: carbonyl group

Guideline Objective

The student will be expected to explain the meaning of the following chemical terms as they relate to the chemical basis of life: atom, ion, isotope, electronegativity, molecule, isomer, chemical reaction, functional group, polymer, pure substance, mole, acid, base, pH, buffer.

Item Focus

The student should be able to identify a diagram representing the structural formula of an important functional group.

Item

What functional group is represented by the following structural formula?

- [ ] A. amino
- [ ] B. carbonyl
- [ ] C. carboxyl
- [ ] D. hydroxyl
- [ ] E. sulphydryl

Response/Marking Scheme

Correct response: B

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Functional Groups
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KaMC.15
GUIDELINE OBJECTIVE CODE: 11Ka
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.6, A.10
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: organic molecules amino acids

Guideline Objective

The student will be expected to explain the meaning of the following chemical terms as they relate to the chemical basis of life: atom, ion, isotope, electronegativity, molecule, isomer, chemical reaction, functional group, polymer, pure substance, mole, acid, base, pH, buffer.

Item Focus

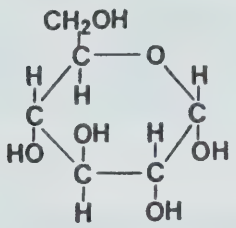
The student should be able to identify a diagram representing the structural formula of an organic compound that contains an amino group.

Item

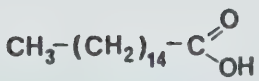
Refer to Figure 1K.1.

ORGANIC COMPOUNDS

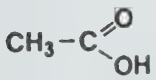
A.



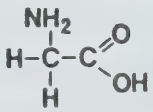
B.



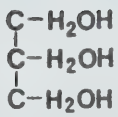
C.



D.



E.



Which organic compound shown in Figure 1K.1 contains an amino group?

- ☐ A.
- ☐ B.
- ☐ C.
- ☐ D.
- ☐ E.

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B011KaMC.16
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 11Ka
UNIT NUMBER: 01	INSTRUMENT TYPE: MC
UNIT NAME: CHEMICAL BASIS OF LIFE	KLOPFER: A.1, A.2
	DIFFICULTY LEVEL: L
TOPIC: Functional Groups	TIME ALLOCATION:
CURRICULAR EMPHASIS: Solid Foundations	
KEYWORDS: amino group amino acid	

Guideline Objective

The student will be expected to explain the meaning of the following chemical terms as they relate to the chemical basis of life: atom, ion, isotope, electronegativity, molecule, isomer, chemical reaction, functional group, polymer, pure substance, mole, acid, base, pH, buffer.

Item Focus

The student should be able to identify the functional groups that are present in amino acids.

Item

An amino acid always has, in addition to an amino group,

- ☐ A. a hydroxyl group.
- ☐ B. a carboxyl group.
- ☐ C. a carbonyl group.
- ☐ D. an aldehyde group.
- ☐ E. a methyl group.

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Functional Groups
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KaMC.17
GUIDELINE OBJECTIVE CODE: .11Ka
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: functional group

Guideline Objective

The student will be expected to explain the meaning of the following chemical terms as they relate to the chemical basis of life: atom, ion, isotope, electronegativity, molecule, isomer, chemical reaction, functional group, polymer, pure substance, mole, acid, base, pH, buffer.

Item Focus

The student should be able to recognize the structure of functional groups.

Item

To which of the following functional groups is the sulfhydryl group most similar?

- [ ] A. amino
- [ ] B. hydroxyl
- [ ] C. acetyl
- [ ] D. carboxyl
- [ ] E. carbonyl

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Functional Groups
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KaMC.18
GUIDELINE OBJECTIVE CODE: 11Ka
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS:

Guideline Objective

The student will be expected to explain the meaning of the following chemical terms as they relate to the chemical basis of life: atom, ion, isotope, electronegativity, molecule, isomer, chemical reaction, functional group, polymer, pure substance, mole, acid, base, pH, buffer.

Item Focus

The student should be able to identify the structure of a particular chemical group.

Item

In which of the following functional groups would you find a hydrogen atom bonded to a nitrogen atom?

- [ ] A. amino
- [ ] B. carbonyl
- [ ] C. carboxyl
- [ ] D. hydroxyl
- [ ] E. sulfhydryl

Response/Marking Scheme

Correct response: A

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B011KaMC.19
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 11Ka
UNIT NUMBER: 01	INSTRUMENT TYPE: MC
UNIT NAME: CHEMICAL BASIS OF LIFE	KLOPFER: A.1, A.2
	DIFFICULTY LEVEL: L
TOPIC: Functional Groups	TIME ALLOCATION:
CURRICULAR EMPHASIS: Solid Foundations	
KEYWORDS:	

Guideline Objective

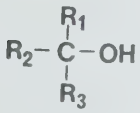
The student will be expected to explain the meaning of the following chemical terms as they relate to the chemical basis of life: atom, ion, isotope, electronegativity, molecule, isomer, chemical reaction, functional group, polymer, pure substance, mole, acid, base, pH, buffer.

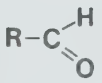
Item Focus

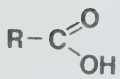
The student should be able to identify a carboxyl group from its structural formula.

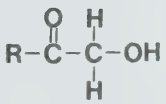
Item

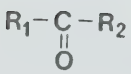
Refer to Figure 1K.2.

A. 

D. 

B. 

E. 

C. 

Which of the formulae shown in Figure 1K.2 contains a carboxyl group?

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Functional Groups
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KaMC.20
GUIDELINE OBJECTIVE CODE: 11Ka
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: amino acid functional group

Guideline Objective

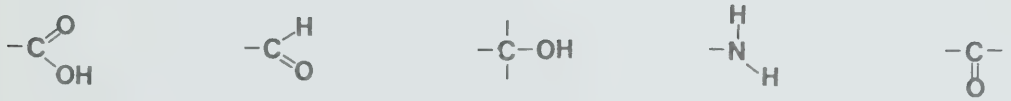
The student will be expected to explain the meaning of the following chemical terms as they relate to the chemical basis of life: atom, ion, isotope, electronegativity, molecule, isomer, chemical reaction, functional group, polymer, pure substance, mole, acid, base, pH, buffer.

Item Focus

The student should be able to identify the structural formulae of the functional groups characteristic of an amino acid.

Item

Refer to Figure 1K.3.



Which of the functional groups shown in Figure 1K.3 are always present in an amino acid?

- [ ] A. I, II, and IV.
- [ ] B. II, and III.
- [ ] C. II, IV, and V.
- [ ] D. I and IV.
- [ ] E. III and V.

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Buffers and pH
CURRICULAR EMPHASIS: Solid Foundations
KEYWORDS: homeostasis

INSTRUMENT CODE: B011KaMC.21
GUIDELINE OBJECTIVE CODE: 11Ka
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: H
TIME ALLOCATION:

Guideline Objective

The student will be expected to explain the meaning of the following chemical terms as they relate to the chemical basis of life: atom, ion, isotope, electronegativity, molecule, isomer, chemical reaction, functional group, polymer, pure substance, mole, acid, base, pH, buffer

Item Focus

The student should be able to identify the role of buffers and the effects on pH of the mixing of different solutions.

Item

To maintain homeostasis, organisms use buffers to keep the pH of their body fluids within narrow limits. A biology student was investigating the control of pH by buffering. The student mixed 200 mL of a buffered solution with a pH of 4 (Solution A) with 200 mL of a base (Solution B). After mixing, the pH of the resulting solution (Solution C) was found to have risen to 5. Which of the following statements can be made in connection with the experiment described?

I	The pH of solution B was 8.
II	Solution B used up all of the buffering action of Solution A.
III	Solution C contains a higher concentration of hydronium ions than Solution A.
IV	There were 10 times as many hydronium ions in Solution A per unit volume than there are in Solution C.
V	Solution C contains more hydroxyl ions per unit volume than Solution B.

Which of the above statements are correct?

- ☐ A. II and IV only.
- ☐ B. I, II, and V only.
- ☐ C. III and IV only.
- ☐ D. II, III, and IV only.
- ☐ E. I, II, III, IV, and V.

Response/Marking Scheme

Correct response: A

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Chemical Reactions
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KaMC.22
GUIDELINE OBJECTIVE CODE: 11Ka
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: neutralization

Guideline Objective

The student will be expected to explain the meaning of the following chemical terms as they relate to the chemical basis of life: atom, ion, isotope, electronegativity, molecule, isomer, chemical reaction, functional group, polymer, pure substance, mole, acid, base, pH, buffer.

Item Focus

The student should be able to identify four types of chemical reactions that occur in an organism's metabolism.

Item

Which of the following equations is an example of a neutralization reaction?

☐ A. $HCOOH + CH_3OH \longrightarrow CH_3OOCH + H_2O$

☐ B. $NH_2CH_2COOH + NH_2CH_2COOH \longrightarrow NH_2CH_2CONHCH_2COOH + H_2O$

☐ C. $CH_3OOCH + H_2O \longrightarrow HCOOH + CH_3OH$

☐ D. $2H_3PO_4 \longrightarrow H_2PO_3OO_3PH_3 + H_2O$

☐ E. $2CH_3CH_2OH \longrightarrow CH_3CHOCHCH_3 + H_2O$

Response/Marking Scheme

Correct response: A

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Chemical Reactions
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KaMC.23
GUIDELINE OBJECTIVE CODE: 11Ka
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: base

Guideline Objective

The student will be expected to explain the meaning of the following chemical terms as they relate to the chemical basis of life: atom, ion, isotope, electronegativity, molecule, isomer, chemical reaction, functional group, polymer, pure substance, mole, acid, base, pH, buffer.

Item Focus

The student should be able to identify the characteristics of a base.

Item

Some of the following are characteristics of a base.

I It is a proton donor.
II It is a proton acceptor.
III It reacts with an acid to produce a salt.
IV It consists of a solution of hydroxyl ions and ions of a metal.
V It has a pH greater than 7.

Which of the following groupings is correct?

☐ A. I, III, and IV

☐ B. I, II, IV, and V

☐ C. II, III, and V

☐ D. III, IV, and V

☐ E. II, III, IV, and V

Response/Marking Scheme

Correct response: E

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Chemical Reactions
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KaMC.24
GUIDELINE OBJECTIVE CODE: 11Ka
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: acid

Guideline Objective

The student will be expected to explain the meaning of the following chemical terms as they relate to the chemical basis of life: atom, ion, isotope, electronegativity, molecule, isomer, chemical reaction, functional group, polymer, pure substance, mole, acid, base, pH, buffer.

Item Focus

The student should be able to identify the characteristics of an acid.

Item

Which of the following are characteristics of an acid?

I It is a proton donor.
II It is a proton acceptor.
III It reacts with a base to produce a salt.
IV It consists of a solution of hydronium ions and ions of a non-metal.
V It can participate in a neutralization reaction to produce a base.

Which of the following groupings is correct?

☐ A. I, III, and IV

☐ B. II, III, and IV

☐ C. III, IV, and V

☐ D. II, IV, and V

☐ E. I, III, and V

Response/Marking Scheme

Correct response: A

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Buffers
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KaMC.25
GUIDELINE OBJECTIVE CODE: 11Ka
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: homeostasis

Guideline Objective

The student will be expected to explain the meaning of the following chemical terms as they relate to the chemical basis of life: atom, ion, isotope, electronegativity, molecule, isomer, chemical reaction, functional group, polymer, pure substance, mole, acid, base, pH, buffer.

Item Focus

The student should be able to identify the role of buffers in living organisms.

Item

Buffers in living organisms

☐ A. maintain cytoplasm in a fluid condition.

☐ B. allow the pH of cells to change without affecting the action of the enzymes.

☐ C. maintain pH in the cells within a narrow range, allowing enzymes to function efficiently.

☐ D. neutralize the effect of enzymes.

☐ E. prevent charged particles from entering the cells.

Response/Marking Scheme

Correct response: C

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Chemical Reactions
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KaMC.26
GUIDELINE OBJECTIVE CODE: 11Ka
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.6
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: buffer

Guideline Objective

The student will be expected to explain the meaning of the following chemical terms as they relate to the chemical basis of life: atom, ion, isotope, electronegativity, molecule, isomer, chemical reaction, functional group, polymer, pure substance, mole, acid, base, pH, buffer.

Item Focus

The student should be able to identify the mechanism of action of buffers.

Item

The chemical components of a buffer are able to

☐ A. combine loosely with H_3O^+ ions.

☐ B. combine loosely with OH^- ions.

☐ C. combine loosely with both H_3O^+ and OH^- ions.

☐ D. generate H_3O^+ ions.

☐ E. generate OH^- ions.

Response/Marking Scheme

Correct response: C

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Basic Chemical Concepts
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KaMC.27
GUIDELINE OBJECTIVE CODE: 11Ka
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.8, D.4
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: enzyme pH

Guideline Objective

The student will be expected to explain the meaning of the following chemical terms as they relate to the chemical basis of life: atom, ion, isotope, electronegativity, molecule, isomer, chemical reaction, functional group, polymer, pure substance, mole, acid, base, pH, buffer.

Item Focus

The student should be able to predict the effects of pH on molecules of proteins.

Item

An enzyme could bear both positive and negative charges upon its molecule at pH values of

- [ ] A. 1.
- [ ] B. 7.
- [ ] C. 13.
- [ ] D. 1, 7, and 13.
- [ ] E. 1 and 13.

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Basic Chemical Concepts
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KaMC.28
GUIDELINE OBJECTIVE CODE: 11Ka
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.8
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: pH hydronium ion

Guideline Objective

The student will be expected to explain the meaning of the following chemical terms as they relate to the chemical basis of life: atom, ion, isotope, electronegativity, molecule, isomer, chemical reaction, functional group, polymer, pure substance, mole, acid, base, pH, buffer.

Item Focus

The student should be able to identify the meaning of the pH scale.

Item

By what factor would the concentration of hydrogen (hydronium) ions be decreased if the pH of a solution changed from 2.0 to 4.0?

- [ ] A. 2
- [ ] B. 6
- [ ] C. 8
- [ ] D. 20
- [ ] E. 100

Response/Marking Scheme

Correct response: E

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Enzymes
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B011KaMC.29
GUIDELINE OBJECTIVE CODE: 11Ka
INSTRUMENT TYPE: MC
KLOPFER: A.7, A.10, F.2
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: protein

Guideline Objective

The student will be expected to explain the meaning of the following chemical terms as they relate to the chemical basis of life: atom, ion, isotope, electronegativity, molecule, isomer, chemical reaction, functional group, polymer, pure substance, mole, acid, base, pH, buffer.

Item Focus

The student should be able to understand how the shapes of enzymes are determined experimentally.

Item

In 1984, scientists reported that protein crystals had been grown in an orbiting space laboratory, and that the crystals were 27 to 1000 times the volume of crystals grown at the earth's surface. Such crystals would be most useful in efforts to determine the proteins'

☐ A. three-dimensional shape.

☐ B. mechanism of catalytic action.

☐ C. molecular weight.

☐ D. chemical composition.

☐ E. function within a cell.

Response/Marking Scheme

Correct response: A

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Functional Groups
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KaMC.30
GUIDELINE OBJECTIVE CODE: 11Ka
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: carboxylic acid ketone alcohol aldehyde peptide

Guideline Objective

The student will be expected to explain the meaning of the following chemical terms as they relate to the chemical basis of life: atom, ion, isotope, electronegativity, molecule, isomer, chemical reaction, functional group, polymer, pure substance, mole, acid, base, pH, buffer.

Item Focus

The student should be able to identify biological examples of chemical compounds with specific functional groups.

Item

An oxygen atom, joined by a double bond to a carbon atom, would be a feature of each of the following EXCEPT

- ☐ A. ketones.
- ☐ B. carboxylic acids.
- ☐ C. alcohols.
- ☐ D. aldehydes.
- ☐ E. peptides.

Response/Marking Scheme

Correct response: C

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Buffers and Photosynthesis
CURRICULAR EMPHASIS: Practical Applications

INSTRUMENT CODE: B011KaER.01
GUIDELINE OBJECTIVE CODE: 11Ka
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, D.1, D.3
DIFFICULTY LEVEL: H
TIME ALLOCATION:

KEYWORDS: buffer photosynthesis respiration water hardness

Guideline Objective

The student will be expected to explain the meaning of the following chemical terms as they relate to the chemical basis of life: atom, ion, isotope, electronegativity, molecule, isomer, chemical reaction, functional group, polymer, pure substance, mole, acid, base, pH, buffer.

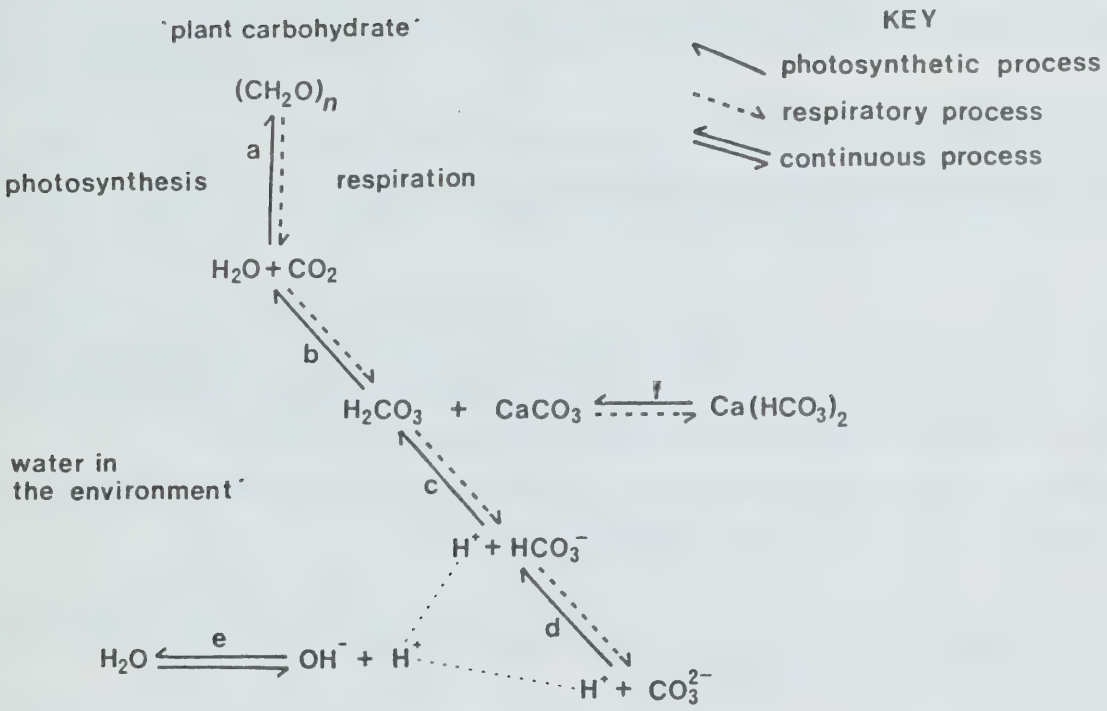
Item Focus

The student should be able to identify and describe relationships among respiration, photosynthesis, buffering and hardness in water.

Item

Refer to Figure 1K.4 to answer this question.

PHOTOSYNTHESIS, RESPIRATION AND HARDNESS



The chemical relationships between water plants (such as Elodea) and water hardness are very complex and are represented, in part, in Figure 1K.4. Answer the questions using only data given in the figure. When answering, make use of the letters **a**, **b**,**c**, ...**f** on the figure to identify specific reactions.

A During photosynthesis, which molecules and/or ions are removed from the water by the plants?

B What effect would the action in reaction **a** have on the acidity and the pH of the water surrounding the plants?

C With respect to pH, what role does the water play when a water plant is actively photosynthesizing?

D During respiration, carbon dioxide is released by plants. What effect will this have on the production of carbonic acid if the plant is not also photosynthesizing? What effect will this have on the pH of the water?

E What function would calcium carbonate, present in the water, serve during plant respiration?

Response/Marking Scheme

A Carbon dioxide molecules and hydronium ions are removed 2
from the water by the plants.

B This would decrease the acidity and raise the pH of the surrounding water. 2

C When a water plant is actively photosynthesizing, water serves to release hydrogen ions to be taken up by the plant. By making available the hydrogen ions, the pH of the surrounding water is stablized and changes very little. 2

D The release of carbon dioxide by a respiring plant (which is not photosynthesizing) will cause a shift in equilibrium of Reactions **b**,**c**, and **d**, resulting in an decrease in the pH of the water. 2

E To offset the increased concentration of carbon dioxide in the water during respiration, available calcium carbonate would combine with the carbonic acid to form calcium bicarbonate (Reaction **f**). 2

By so doing, the calcium carbonate would serve to maintain the pH within a narrow range, thus buffering the aqueous solution. 2

Possible: 12

Maximum: 10

Source: *The School Science Review* Vol. 67, No. 239, December 1985 Page 303.

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Buffers and Photosynthesis
CURRICULAR EMPHASIS: Practical Applications

INSTRUMENT CODE: B011KaER.02
GUIDELINE OBJECTIVE CODE: 11Ka
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, D.1, D.3
DIFFICULTY LEVEL: H
TIME ALLOCATION:

KEYWORDS: buffer photosynthesis respiration water hardness

Guideline Objective

The student will be expected to explain the meaning of the following chemical terms as they relate to the chemical basis of life: atom, ion, isotope, electronegativity, molecule, isomer, chemical reaction, functional group, polymer, pure substance, mole, acid, base, pH, buffer.

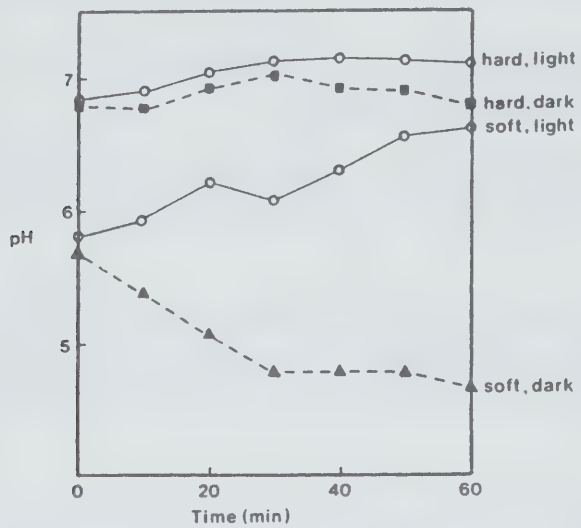
Item Focus

The student should be able to identify and describe relationships among respiration, photosynthesis, buffering and hardness in water.

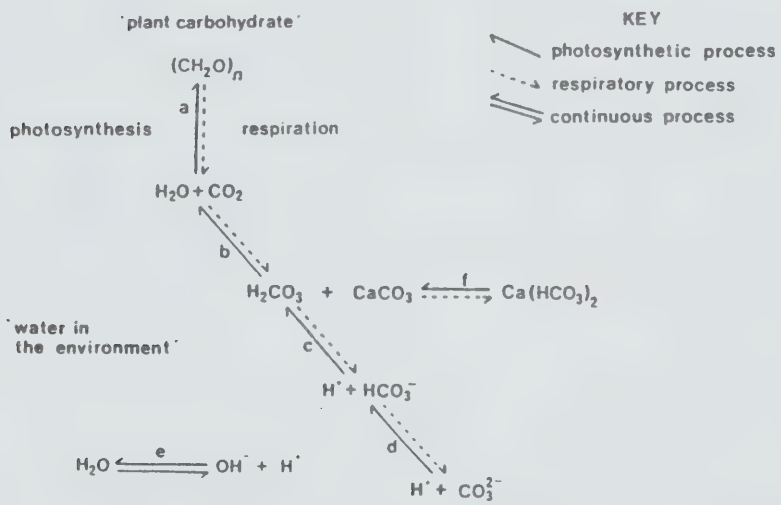
Item

Refer to Figures 1K.4 and 1K.5 to answer this question.

CHANGES IN pH OF THE SOLUTION SURROUNDING THE PLANT



PHOTOSYNTHESIS, RESPIRATION AND HARDNESS



Source:*School Science Review* Vol. 69, No. 239, December 1985, p. 303

The chemical relationships between water plants (such as Elodea), water hardness, and pH are very complex. Results from a student lab activity employing Elodea are shown in Figure 1K.5. Examine this figure closely and, making use of the background information in Figure 1K.4, answer the following questions based on it.

A. Account for the observation that the pH of soft water surrounding an aquatic plant decreases more over time in the dark than in the light.

B. Account for the observation that the pH of hard water surrounding an aquatic plant differs relatively little when the plants and the water are placed in the light or in the dark.

C. Based on respiration and photosynthesis and the information in Figure 1K.4, predict what would happen to the concentration of oxygen in hardwater surrounding an aquatic plant over time. Assume that the plant is in the light.

D. Based on the information in Figure 1K.4, predict what would happen to the concentration of oxygen in soft water surrounding an aquatic plant over time. Assume that the plant is in the dark.

Response/Marking Scheme

A. If a plant is in soft water, there is little or no buffering quality to this water. (This is supported by the graphed data.) 1

When the plant is in the dark, photosynthesis is not taking place but respiration continues to occur. The carbon dioxide released during 1

respiration will form carbonic acid (Figure 1K.4) 1

and this will cause the pH to decrease. 1

B. When the plant is in the light it is taking in both carbon dioxide and hydrogen ions. 2

This would normally tend to raise the pH but more hydrogen ions are released from the water. As a result, the 1

water tends to maintain a pH within a relatively narrow range. 1

C. If the plant is in the light, the rate of photosynthesis will exceed the rate of respiration. 1

As a result, the plant will take in carbon dioxide and hydrogen ions (Figure 1K.4) 1

and release oxygen. Thus the oxygen concentration in the water will increase over time. 1

The calcium carbonate does not play any role in altering the oxygen concentration in the water. 1

D. If the plant is in the dark, only respiration is taking place. Thus, carbon dioxide is 1

being given off to the surrounding water, and oxygen is taken from the water. 1

Over time, the concentration of oxygen in the water will decrease. 1

The calcium carbonate does not play any role in altering the oxygen concentration. 1

Possible: 16

Maximum: 12

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Types of Reactions
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KaER.03
GUIDELINE OBJECTIVE CODE: 11Ka 11Kc 11Kg

INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.3, A.6
DIFFICULTY LEVEL: H
TIME ALLOCATION:

KEYWORDS: neutralization oxidation/reduction dehydration synthesis condensation hydrolysis.

Guideline Objective

The student will be expected to explain the meaning of the following chemical terms as they relate to the chemical basis of life: atom, ion, isotope, electronegativity, molecule, isomer, chemical reaction, functional group, polymer, pure substance, mole, acid, base, pH, buffer.

Item Focus

The student should be able to name and summarize the nature and importance of four basic types of chemical reactions.

Item

Construct a table to summarize four major types of chemical reactions important in biology. For each type, give

A. the generally accepted name for the type,

B. a word summary of the chemical changes occurring,

C. an example of the occurrence of the reaction in a biological process.

Response/Marking Scheme

REACTION TYPE	CHEMICAL CHANGES	BIOLOGICAL PROCESSES
neutralization	acid+base ⟶ water+ salt	stomach acid neutralized by bile, pancreatic juice in duodenum
oxidation/reduction	hydrogen atoms or electrons transferred between reactants	energy storage and transfer in cells
hydrolysis	large molecule split into two smaller ones; water added at split	digestion: breakdown to smaller molecules of fewer kinds for active transport
dehydration synthesis (condensation)	two molecules joined; water removed from site of union	construction of macromolecules for storage of energy, or information, or regulatory enzymes.

MARKS:

4 x 1	4 x 2	4 x 1
=4	=8	=4

Maximum: 16

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Types of Reactions
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KaER.04
GUIDELINE OBJECTIVE CODE: 11Ka 11Kg
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, A.6
DIFFICULTY LEVEL: H
TIME ALLOCATION:

KEYWORDS: metabolism neutralization oxidation/reduction condensation hydrolysis

Guideline Objective

The student will be expected to explain the meaning of the following chemical terms as they relate to the chemical basis of life: atom, ion, isotope, electronegativity, molecule, isomer, chemical reaction, functional group, polymer, pure substance, mole, acid, base, pH, buffer.

Item Focus

The student should be able to relate chemical reactions to life processes.

Item

Name four major types of biochemical reactions that occur during the metabolism of an organism, and for each of them, describe two different metabolic processes that involve that type of reaction.

Response/Marking Scheme

Four types of reaction: neutralization, oxidation-reduction, dehydration synthesis (condensation), and hydrolysis. (Accept other valid responses). 4

Neutralization:

1. buffering (maintaining pH within the body and cells) 1
2. regulating movements of ions through membranes. 1

Oxidation-reduction:

1. in the storage and release of energy. 1
2. alteration of physical/chemical properties of cell metabolites. 1

Dehydration Synthesis (Condensation): (any two of the following) 2

1. joining molecules together to form suitable substrates in such metabolic cycles as the Calvin cycle.
2. forming macromolecules that are used for information storage or transfer (DNA, RNA).
3. forming macromolecules (enzymes) used for catalyzing reactions.
4. forming macromolecules for efficient energy storage.
5. forming macromolecules for structural uses.
6. for transport of substances of low solubility in water.

Hydrolysis:

1. in digestion, to reduce the size of large molecules for absorption. 1
2. to reduce used nucleotides to nucleic acids that can be recycled. 1

Maximum: 12

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Buffers
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KaER.05
GUIDELINE OBJECTIVE CODE: 11Ka
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: pH enzyme homeostasis

Guideline Objective

The student will be expected to explain the meaning of the following chemical terms as they relate to the chemical basis of life: atom, ion, isotope, electronegativity, molecule, isomer, chemical reaction, functional group, polymer, pure substance, mole, acid, base, pH, buffer.

Item Focus

The student should be able to define "buffer" and explain the effect of pH changes on the activity of enzymes.

Item

A What is the function of buffers in the fluids of organisms?

B How do buffers perform their function, and why are they essential to the life of an organism?

Response/Marking Scheme

A Buffers are compounds that prevent fluctuations	1
in the pH of body fluids,	1
B For the maintenance of many biochemical reactions in organisms, it is essential to keep the pH within narrow limits for enzymes to function.	2
By either absorbing or releasing hydrogen ions,	2
buffers control the pH of fluids to within 0.3 above or below pH of 7.4.	1
Beyond this range, the alteration of an enzyme might irreversibly inactivate it; this	1
might disrupt an entire metabolic sequence, proving fatal to the organism.	1
Possible:	9
Maximum:	7

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Buffers
CURRICULAR EMPHASIS: Solid Foundations
KEYWORDS: pH

INSTRUMENT CODE: B011KaER.06
GUIDELINE OBJECTIVE CODE: 11Ka
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, D.3
DIFFICULTY LEVEL: M
TIME ALLOCATION:

Guideline Objective

The student will be expected to explain the meaning of the following chemical terms as they relate to the chemical basis of life: atom, ion, isotope, electronegativity, molecule, isomer, chemical reaction, functional group, polymer, pure substance, mole, acid, base, pH, buffer.

Item Focus

The student should be able to explain a proposed mechanism for buffered solutions resisting pH changes.

Item

A. Define the term buffer as it applies to a living system.

B. Why are living systems so susceptible to even slight changes in pH?

C. Describe a mechanism to account for the fact that a buffered solution can resist changes in pH, involving sodium acetate as an example.

Response/Marking Scheme

A. A buffer is a solution to which it is 1
possible to add either hydronium ions 1
or hydroxyl ions with minimal effect 1
on the pH of the solution. (or other acceptable definition.)

B. The reason for this lies in the fact that most enzymes metabolize reactions in a very narrow pH range. (Expressed in another way, beyond this narrow range, the protein is denatured.) 2

C. An effective buffer system consists of a weak acid (eg., acetic acid) and a salt made from that acid (eg., sodium acetate). In solution, the components of the system can be represented as follows:

$NaAc \longrightarrow Na^{+}(aq) + Ac^{-}(aq)$ 2
$HAc \rightleftharpoons H_3O + (aq) + Ac^{-}(aq)$ 2
The acid is partially dissociated and the 1
salt is completely dissociated. 1
If additional hydronium ions are added 1
to the system, they will combine with the acetate ions to form undissociated acetic 2
acid.

If additional hydroxyl ions are added to 1
the system, they will combine with the 1
hydronium ions thus forming water. The 1
system reaches a new equilibrium point by 1
replacing the hydronium ions with some 1
generated from the partial dissociation 1
of the acetic acid in the system. 1

Possible: 21

Maximum: 13

Quality: 2

Total: 15

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Biologically Important Molecules
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B011KaER.07
GUIDELINE OBJECTIVE CODE: 11Ac 11Ka 31Ad Part 1 (3.2 -8e, 3.3A)
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, A.5
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: reactivity polymerization monomer

Guideline Objective

The student will be encouraged to develop an interest in the biochemical nature-of-life processes.

Item Focus

The student should be able to explain a trend in reactivity that accompanies polymerization.

Item

Scientists are interested in revealing trends or patterns that exist in natural phenomena. For example, it is found that the reactivity of important monomers (such as glucose) decreases when the monomers are polymerized. For example, starch is not as chemically reactive as glucose. Account for the reduction of reactivity as polymerization occurs.

Response/Marking Scheme

Chemical reactivity in biological systems is related to the solubility of a substance in water; in general, the greater the solubility, the greater the reactivity. 1

Two major factors that affect solubility of substances in biological systems are the molecular weight and the charge- density ratio of the compound. 2

Empirically, as the molecular weight increases, the solubility of a substance decreases. 1

As the charge-density of a substance decreases, the solubility of the substance decreases. 1

Polymerization of a compound such as glucose results in an increase in molecular weight of the resulting polymer and a decrease in the charge-density ratio; both conditions result in a reduction of solubility, hence a reduction in chemical activity. 1

Possible: 6

Maximum: 5

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Functional Groups and Linkages
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KaMA.01
GUIDELINE OBJECTIVE CODE: 11Ka
INSTRUMENT TYPE: MA
KLOPFER: A.1, A.2, A.6
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: functional groups

Guideline Objective

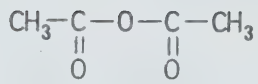
The student will be expected to explain the meaning of the following chemical terms as they relate to the chemical basis of life: atom, ion, isotope, electronegativity, molecule, isomer, chemical reaction, functional group, polymer, pure substance, mole, acid, base, pH, buffer.

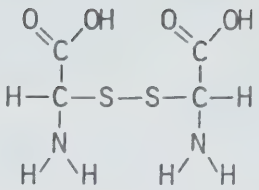
Item Focus

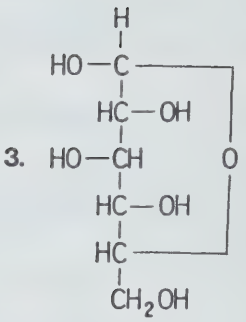
The student should be able to recognize functional groups within a molecule.

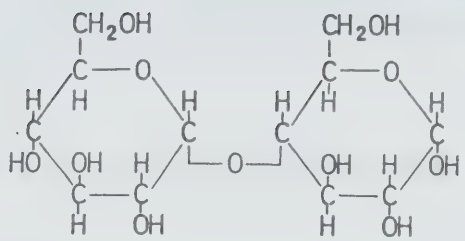
Item

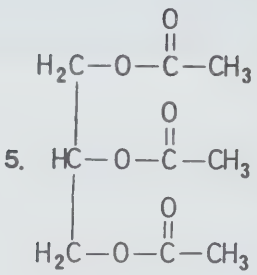
Refer to Figure 1K.6.

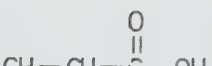
1. 

2. 

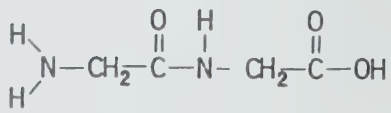
3. 

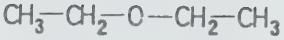
4. 

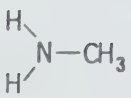
5. 

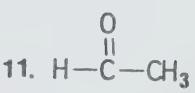
6. 

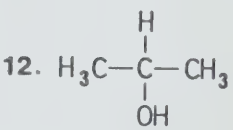
7.

8. 

9. 

10. 

11. 

12. 

For each of the following functional groups, select one molecule in Fig. 1K.6 that contains the functional group and place its number in the space provided.

a) carbonyl (in a ketone) _____

b) carbonyl (in an aldehyde) _____

c) carboxyl _____

d) alcohol _____

e) amino _____

Response/Marking Scheme

a)	carbonyl	(ketone)	7,
b)	carbonyl	(aldehyde)	11
c)	carboxyl	(one of)	2, 6, 8
d)	alcohol	(one of)	3, 4, 12
e)	amino	(one of)	2, 8, 10

Maximum: 5

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Functional Groups
CURRICULAR EMPHASIS: Communication

INSTRUMENT CODE: B011KaSA.01
GUIDELINE OBJECTIVE CODE: 11Ka
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: functional groups

Guideline Objective

The student will be expected to explain the meaning of the following chemical terms as they relate to the chemical basis of life: atom, ion, isotope, electronegativity, molecule, isomer, chemical reaction, functional group, polymer, pure substance, mole, acid, base, pH, buffer.

Item Focus

The student should be able to draw structural formulae to represent important functional groups.

Item

Draw structural formulae to represent each of the following functional groups:

A. amino

B. carbonyl

C. carboxyl

D. hydroxyl

E. sulphydryl

Response/Marking Scheme

A.

B.

C.

D. $-OH$

E. $-SH$

Maximum: 5

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Functional Groups
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KaSA.02
GUIDELINE OBJECTIVE CODE: 11Ka
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.6
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: functional group

Guideline Objective

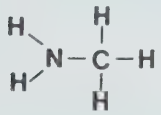
The student will be expected to explain the meaning of the following chemical terms as they relate to the chemical basis of life: atom, ion, isotope, electronegativity, molecule, isomer, chemical reaction, functional group, polymer, pure substance, mole, acid, base, pH, buffer.

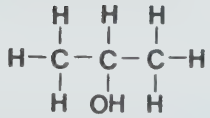
Item Focus

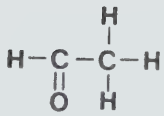
The student should be able to identify the functional groups of a molecule.

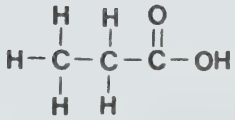
Item

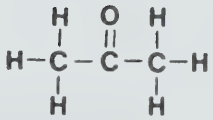
Circle the functional groups (except hydrocarbons) in each of the following molecules and give the names of the group in the spaces provided beside the molecular structures. Do not circle any hydrocarbon group.

A. 

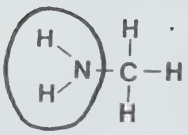
B. 

C. 

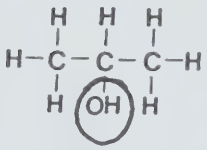
D. 

E. 

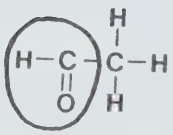
Response/Marking Scheme

A. 

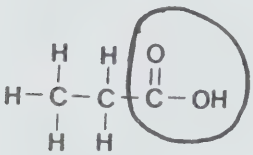
amino

B. 

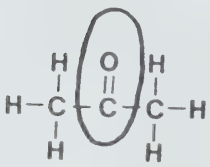
hydroxyl

C. 

carbonyl (aldehyde)

D. 

carboxyl

E. 

carbonyl (ketone)

Maximum: 5

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Basic Chemical Concepts
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KaSA.03
GUIDELINE OBJECTIVE CODE: 11Ka
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.3, A.6
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: isomers hydrocarbons

Guideline Objective

The student will be expected to explain the meaning of the following chemical terms as they relate to the chemical basis of life: atom, ion, isotope, electronegativity, molecule, isomer, chemical reaction, functional group, polymer, pure substance, mole, acid, base, pH, buffer.

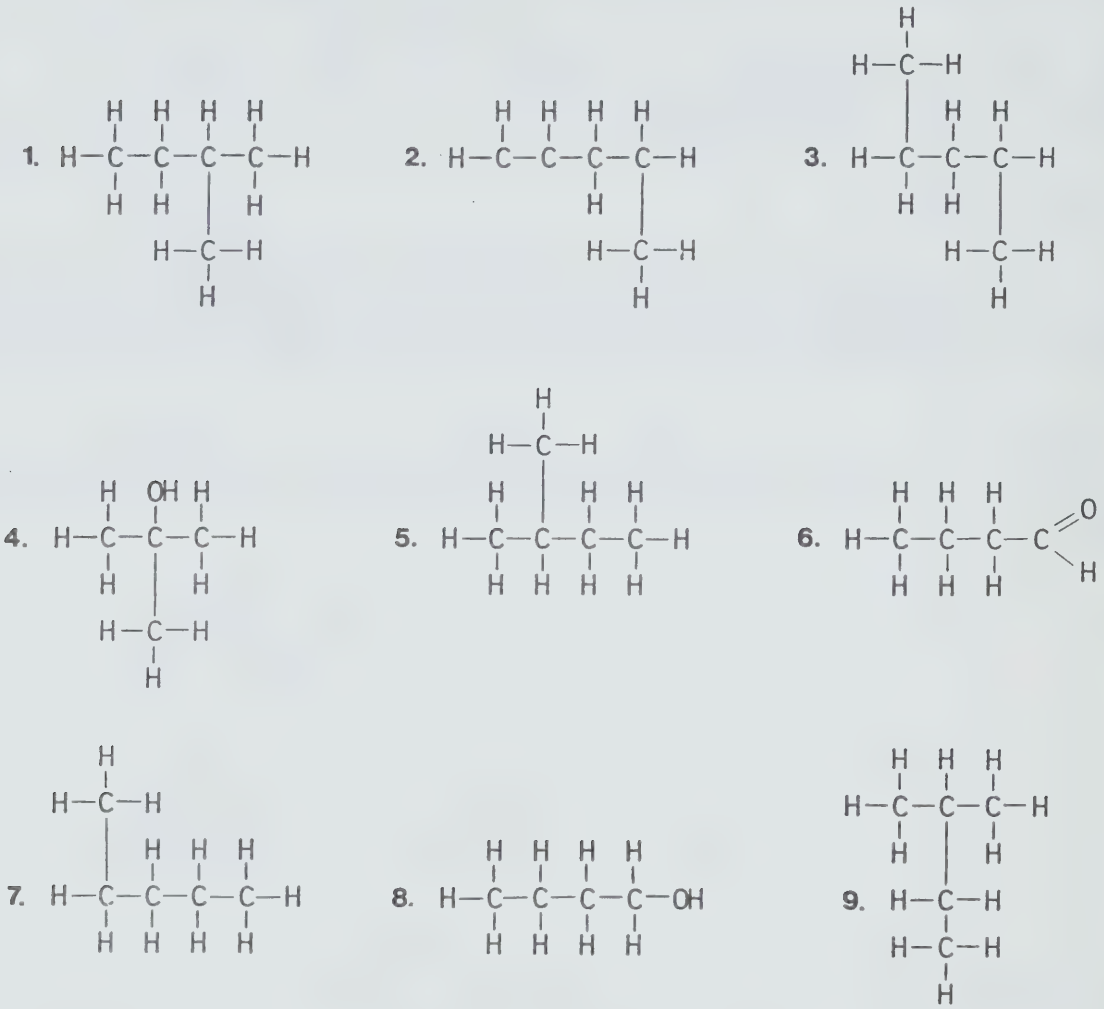
Item Focus

The student should be able to identify isomers and hydrocarbons from their structural formulae.

Item

Refer to Figure 1K.7.

STRUCTURAL FORMULAE



Which of the structural formulae in Figure 1K.7

A. are identical to the structure shown in #1?

B. are isomers of the structure shown in #7?

C. are isomers of the structure shown in #8?

D. represent hydrocarbons?

NOTE: Incorrect responses will be subtracted from correct responses.

Response/Marking Scheme

1 mark for each correct response, minus 1 mark for each incorrect response.

A. 5, 9.

B. 1, 5, 9.

C. 4

D. 1, 2, 3, 5, 7, 9.

Maximum: 12

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Chemical Bonds
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KbER.01
GUIDELINE OBJECTIVE CODE: 11Kb
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, A.5, A.9
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: bonds electronegativity combining capacity (valence)

Guideline Objective

The student will be expected to explain briefly, in terms of electronegativity and stable electron configurations, why atoms interact.

Item Focus

Same as above.

Item

In the biological compounds you have studied, hydrogen atoms form only one bond with other atoms, oxygen atoms form two bonds, nitrogen atoms form three bonds and carbon atoms form four bonds. Explain why hydrogen, oxygen, nitrogen and carbon bond in these ways.

Response/Marking Scheme

Atoms of different elements have different numbers of electrons in their outermost shell. 1

In a chemical reaction, bond formation stops
when each atom has filled its outermost shell 1

until it resembles an inert gas. 1

While this might be done either by adding or withdrawing electrons to/from the atom, 1

the atoms named all have high electronegativites. 1

Hence, each tends to gain electrons 1

in a chemical reaction rather than lose them. The numbers given correspond to
the numbers of electrons to be added by each element
to achieve the configuration of an inert gas. 1

Helium in the case of hydrogen 1

and neon in the other cases cited. 1

Possible: 9

Maximum: 6

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Chemical Reactions
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KcMC.01
GUIDELINE OBJECTIVE CODE: 11Kc 21Ke
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: oxidation reduction

Guideline Objective

The student will be expected to identify and describe examples of oxidation and reduction reactions that occur in living organisms.

Item Focus

The student should be able to identify the concept of energy relationships in oxidation/reduction reactions.

Item

In a typical oxidation/reduction reaction, for example, in aerobic respiration, the energy

☐ A. given off is all lost as heat energy.

☐ B. released in oxidation is greater than that required for reduction.

☐ C. contained in the products is greater than that contained in the reactants.

☐ D. required for reduction is the same as that released in oxidation.

☐ E. of the system contains more free energy at the end of the reaction.

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Oxidation/Reduction
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KcMC.02
GUIDELINE OBJECTIVE CODE: 11Kc 21Ke
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: aerobic respiration ion cytochrome

Guideline Objective

The student will be expected to identify and describe examples of oxidation and reduction reactions that occur in living organisms.

Item Focus

The student should be able to identify a reduction reaction from a change in valence.

Item

During aerobic cellular respiration, a Fe^{3+} ion in a cytochrome molecule changes to a Fe^{2+} ion. The process that has taken place is

☐ A. neutralization.

☐ B. isomerism.

☐ C. oxidation.

☐ D. reduction.

☐ E. isotope formation.

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Chemical Reactions
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KcMC.03
GUIDELINE OBJECTIVE CODE: 11Kc 21Kh
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: ATP energy

Guideline Objective

The student will be expected to identify and describe examples of oxidation and reduction reactions that occur in living organisms.

Item Focus

The student should be able to identify a chemical reaction that occurs in organisms that does not use ATP as its energy source.

Item

All of the following processes, EXCEPT ONE, use ATP as their source of energy. Which one does NOT use ATP?

- [ ] A. reduction of functional groups
- [ ] B. dehydration synthesis (condensation)
- [ ] C. active transport
- [ ] D. muscle contraction
- [ ] E. bioluminescence

Response/Marking Scheme

Correct response: A

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Chemical Reactions
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KcMC.04
GUIDELINE OBJECTIVE CODE: 11Kc 21Ke
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.5, A.7
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: oxidation reduction

Guideline Objective

The student will be expected to identify and describe examples of oxidation and reduction reactions that occur in living organisms.

Item Focus

The student should be able to identify an oxidation/reduction reaction.

Item

What type of chemical reaction is illustrated by the following reaction?

$C_6H_{12}O_6 + 6H_2O + 6O_2 \rightarrow 12H_2O + 6CO_2$

- [ ] A. oxidation/reduction
- [ ] B. substitution
- [ ] C. neutralization
- [ ] D. hydrolysis
- [ ] E. dehydration synthesis (condensation)

Response/Marking Scheme

Correct response: A

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Chemical Reactions
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KcMC.05
GUIDELINE OBJECTIVE CODE: 11Kc 21Ke
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: oxidation reduction

Guideline Objective

The student will be expected to identify and describe examples of oxidation and reduction reactions that occur in living organisms.

Item Focus

The student should be able to recognize an oxidation reaction.

Item

All of the following are oxidizing reactions except one. Which one is NOT an oxidizing reaction?

- [ ] A. a forest fire
- [ ] B. a rusting nail
- [ ] C. the yellowing of paper as it ages
- [ ] D. the utilization of glucose in a cell
- [ ] E. the manufacture of glucose in a green plant

Response/Marking Scheme

Correct response: E

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Chemical Reactions
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KcMC.06
GUIDELINE OBJECTIVE CODE: 11Kc 21Ke
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: oxidation/reduction

Guideline Objective

The student will be expected to identify and describe examples of oxidation and reduction reactions that occur in living organisms.

Item Focus

The student should be able to identify a chemical reaction in which oxidation/reduction has occurred.

Item

In which one of the following has oxidation/reduction occurred?

- [ ] A. A large molecule has been split into two.
- [ ] B. Electrons have been transferred from one molecule or ion to another.
- [ ] C. An acid has reacted with a base to form water and a salt.
- [ ] D. Two molecules have combined to create a large molecule.
- [ ] E. An amino group has reacted with a carboxyl group to form a peptide bond.

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Chemical Reactions
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KcMC.07
GUIDELINE OBJECTIVE CODE: 11Kc 21Ke
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: oxidation/reduction

Guideline Objective

The student will be expected to identify and describe examples of oxidation and reduction reactions that occur in living organisms.

Item Focus

The student should be able to identify an oxidation/reduction reaction from its equation.

Item

What kind of chemical reaction is represented by the following equation?

$$R - CHO + H_2O + NAD^+ \longrightarrow R - COOH + NADH + H^+$$

- [ ] A. Neutralization
- [ ] B. Dehydration synthesis (condensation)
- [ ] C. Hydrolysis
- [ ] D. Deaminization
- [ ] E. Oxidation/reduction

Response/Marking Scheme

Correct response: E

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Chemical Reactions
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KcMC.08
GUIDELINE OBJECTIVE CODE: 11Kc 21Kh
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.10
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: oxidation reduction

Guideline Objective

The student will be expected to identify and describe examples of oxidation and reduction reactions that occur in living organisms.

Item Focus

The student should be able to identify the process of oxidation from a description of the process.

Item

The removal of hydrogen atoms from glucose is an example of

- [ ] A. neutralization.
- [ ] B. dehydration.
- [ ] C. oxidation.
- [ ] D. dehydration synthesis (condensation).
- [ ] E. hydrolysis.

Response/Marking Scheme

Correct response: C

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Oxidation/Reduction
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KcMC.09
GUIDELINE OBJECTIVE CODE: 11Kc
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: oxidation reduction

Guideline Objective

The student will be expected to identify and describe examples of oxidation and reduction reactions that occur in living organisms.

Item Focus

The student should be able to identify the substance that is oxidized in an oxidation/reduction equation.

Item

In photosynthesis, water molecules are split as follows:

$H_2O + NADP^+ \rightarrow NADPH + H^+ + O_2$

In the above equation, what undergoes reduction?

☐ A. the water molecules

☐ B. the $NADP^+$

☐ C. the oxygen that is released

☐ D. the NADPH

☐ E. the hydrogen ions (protons)

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Oxidation/Reduction
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KcMC.10
GUIDELINE OBJECTIVE CODE: 11Kc 21Ke
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: oxidation oxidizing agent reducing agent electron

Guideline Objective

The student will be expected to identify and describe examples of oxidation and reduction reactions that occur in living organisms.

Item Focus

The student should be able to identify the key aspect of oxidation in a biological system.

Item

Oxidation is a process in which

- [ ] A. there is a loss of electrons.
- [ ] B. the reducing agent loses electrons.
- [ ] C. the oxidizing agent loses electrons.
- [ ] D. energy is released.
- [ ] E. energy is lost.

Response/Marking Scheme

Correct response: A

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Oxidation/Reduction
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KcMC.11
GUIDELINE OBJECTIVE CODE: 11Kc 21Ke
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.10
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: oxidation reduction

Guideline Objective

The student will be expected to identify and describe examples of oxidation and reduction reactions that occur in living organisms.

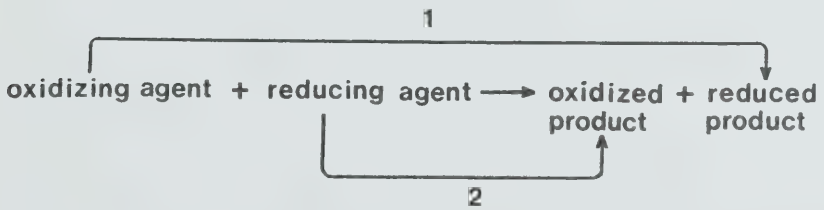
Item Focus

The student should be able to identify the substance reduced, given a generalized equation.

Item

Refer to Figure 1K.8.

OXIDATION/REDUCTION REACTION



The best label for Number 1 in Figure 1K.8 could be

- [ ] A. oxidation, loss of electrons.
- [ ] B. reduction, gain of electrons.
- [ ] C. oxidation, gain of electrons.
- [ ] D. reduction, loss of electrons.
- [ ] E. neither oxidation nor reduction.

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Oxidation/Reduction
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KcMC.12
GUIDELINE OBJECTIVE CODE: 11Kc 21Ke
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, F.1
DIFFICULTY LEVEL: H
TIME ALLOCATION:

KEYWORDS: oxidized reduced

Guideline Objective

The student will be expected to identify and describe examples of oxidation and reduction reactions that occur in living organisms.

Item Focus

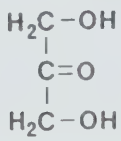
The student should be able to identify compounds that are relatively more oxidized, or more reduced.

Item

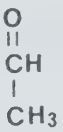
Refer to Figure 1K.9.

STRUCTURAL FORMULAE OF ORGANIC COMPOUNDS

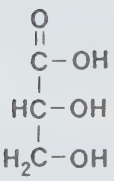
1.



4.

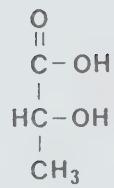


2.



5. $O=C=O$

3.



The compounds shown in Figure 1K.9 are involved in respiration

If the numbered compounds in Figure 1K.9 were arranged in order from the most oxidized to the most reduced, the correct sequence would be as follows:

- ☐ A. 1, 2, 3, 4, 5
- ☐ B. 5, 4, 3, 2, 1
- ☐ C. 1, 3, 2, 4, 5
- ☐ D. 5, 4, 1, 2, 3
- ☐ E. 5, 4, 1, 3, 2

Response/Marking Scheme

Correct response: E

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Oxidation
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KcMC.13
GUIDELINE OBJECTIVE CODE: 11Kc 21Ke
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: oxidation

Guideline Objective

The student will be expected to identify and describe examples of oxidation and reduction reactions that occur in living organisms.

Item Focus

The student should be able to identify aspects of oxidation as it relates to biological systems.

Item

In biological systems, oxidation involves

- [ ] A. loss of hydrogen atoms.
- [ ] B. gain of electrons.
- [ ] C. gain of hydrogen atoms.
- [ ] D. free oxygen.
- [ ] E. loss of oxygen atoms.

Response/Marking Scheme

Correct response: A

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Oxidation/Reduction
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KcMC.14
GUIDELINE OBJECTIVE CODE: 11Kc 21Ke
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: oxidized

Guideline Objective

The student will be expected to identify and describe examples of oxidation and reduction reactions that occur in living organisms.

Item Focus

Same as above.

Item

A molecule is said to have become oxidized when it

- [ ] A. gains electrons or hydrogen atoms.
- [ ] B. releases oxygen atoms.
- [ ] C. is in the presence of hydrogen molecules.
- [ ] D. releases electrons or hydrogen atoms.
- [ ] E. is in the presence of a reducing agent.

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Role of Co-Enzymes
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KcMC.15
GUIDELINE OBJECTIVE CODE: 11Kc 21Kf
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: oxidation/reduction

Guideline Objective

The student will be expected to identify and describe examples of oxidation and reduction reactions that occur in living organisms.

Item Focus

The student should be able to identify the role of major co-enzymes.

Item

Which substance does NOT participate in redox reactions?

- ☐ A. ATP
- ☐ B. FAD
- ☐ C. Cytochrome *c*
- ☐ D. NAD^+
- ☐ E. $NADP^+$

Response/Marking Scheme

Correct response: A

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Reduction
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KcMC.16
GUIDELINE OBJECTIVE CODE: 11Kc 21Kg
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.10, D.4, F.1
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: $NADP^+$ reduction

Guideline Objective

The student will be expected to identify and describe examples of oxidation and reduction reactions that occur in living organisms.

Item Focus

The student should be able to identify likely sites of reduction in a metabolic sequence.

Item

Refer to Figure 1K.10.

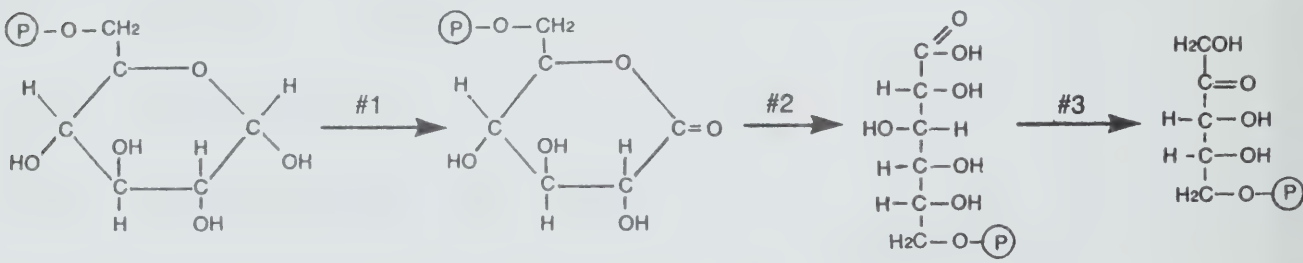


Figure 1K.10 shows three of a series of metabolic reactions occurring in cells. Where in the sequence, could you reasonably expect $NADP^+$ to be reduced as the reaction proceeds?

- A. reaction 1
- B. reaction 2
- C. reaction 3
- D. reaction 1 and also reaction 3
- E. reaction 1, reaction 2, and also reaction 3.

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Decarboxylation
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KcMC.18
GUIDELINE OBJECTIVE CODE: 11Kc 21Kg
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.10, D.4, F.1
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS:

Guideline Objective

The student will be expected to identify and describe examples of oxidation and reduction reactions that occur in living organisms.

Item Focus

The student should be able to identify likely sites of decarboxylation in a metabolic sequence.

Item

Refer to Figure 1K.10.

A SERIES OF METABOLIC REACTIONS

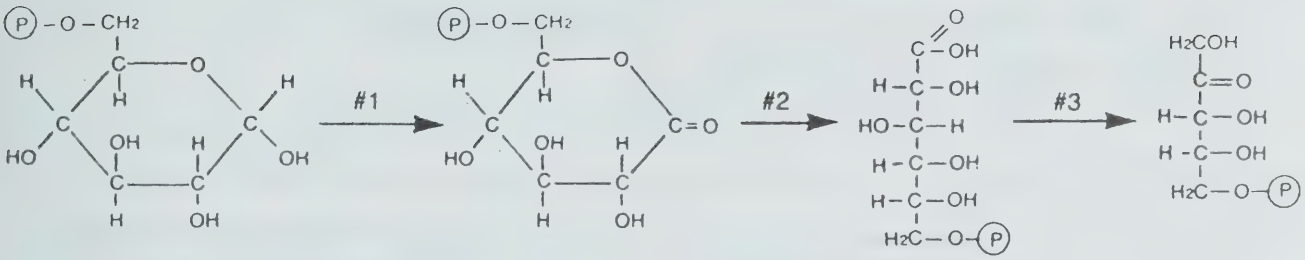


Figure 1K.10 shows three of a series of metabolic reactions occurring in cells. Where, in the sequence, could you reasonably expect to observe decarboxylation?

- A. reaction 1
- B. reaction 2
- C. reaction 3
- D. reaction 1 and also reaction 3
- E. reaction 1, reaction 2, and also reaction 3

Response/Marking Scheme

Correct response: C

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Cellular Respiration
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KcER.01
GUIDELINE OBJECTIVE CODE: 11Kc 21Kg
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, A.9
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: oxidation/reduction coenzyme

Guideline Objective

The student will be expected to identify and describe examples of oxidation and reduction reactions that occur in living organisms.

Item Focus

The student should be able to describe the events surrounding oxidation/reduction during energy transfer in cells.

Item

During cellular respiration, many transfers of energy occur. Coenzyme carrier molecules play a vital role in these transfers. One such molecule is the oxidized form of nicotinamide adenine dinucleotide, NAD^+.

A. Describe what happens when a substrate is oxidized by the coenzyme, NAD^+.

B. After the NAD^+ has been reduced, what is its significance during aerobic respiration?

Response/Marking Scheme

A. The substrate loses 2 hydrogen atoms to each NAD^+. 1

Each hydrogen atom consists of 1 electron and 1 proton (or hydrogen ion, H^+) 1

Both electrons and 1 proton combine with NAD^+ to form NADH. 1

The second proton is released into the surrounding medium. 1

B. The energy now held in the reduced form of the 1

coenzyme (NADH) is used to transport actively hydrogen ions across the inner mitochondrial membrane. 1

This builds up a reservoir of hydrogen ions on one side of the membrane, 1

establishing an electrochemical gradient across the membrane. 1

This gradient provides the energy for the synthesis of ATP from ADP + phosphate. 1

ATP can then provide the energy for the cell to use for a wide variety of activities. 1

Possible: 10

Maximum: 7

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Types of Reactions
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KcSA.01
GUIDELINE OBJECTIVE CODE: 11Kc 11Kg
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.3, A.6
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: neutralization oxidation/reduction condensation hydrolysis.

Guideline Objective

The student will be expected to identify and describe examples of oxidation and reduction reactions that occur in living organisms.

Item Focus

The student should be able to name and summarize the nature and importance of four basic types of chemical reactions.

Item

The table that follows deals with four major types of chemical reactions important in biology. Complete the table, summarizing the appropriate information.

REACTION TYPE	CHEMICAL CHANGES	IMPORTANCE
neutralization		stomach acid is neutralized by bile and pancreatic juice in the duodenum
	hydrogen atoms or electrons transferred between reactants	
hydrolysis		
	two molecules are joined; water removed from site of the union	

Response/Marking Scheme

REACTION TYPE	CHEMICAL CHANGES	IMPORTANCE
neutralization	acid+base → salt+ water 2 marks	stomach acid is neutralized by bile and pancreatic juice in the duodenum
oxidation/reduction 1 mark	hydrogen atoms or electrons transferred between reactants	energy storage and transfer in cells 2 marks
hydrolysis	large molecule is split into two smaller ones; water added at split 2 marks	digestion: breakdown to smaller molecules of fewer kinds for active transport 2 marks
dehydration synthesis (condensation) 1 mark	two molecules are joined; water is removed from site of the union	construction of macro molecules for storage of energy, or genetic information or regulatory enzymes 2 marks

Maximum: 12

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Chemical Reactions
CURRICULAR EMPHASIS: Solid Foundations
KEYWORDS: oxidation/reduction

INSTRUMENT CODE: B011KcSA.02
GUIDELINE OBJECTIVE CODE: 11Kc
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.3, A.5, A.7
DIFFICULTY LEVEL: L
TIME ALLOCATION:

Guideline Objective

The student will be expected to identify and describe examples of oxidation and reduction reactions that occur in living organisms.

Item Focus

The student should be able to identify the processes of oxidation and reduction, and identify the roles played by different compounds in the processes.

Item

In the following chemical reaction,

$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_20$+energy

A. the substance(s) oxidized is/are _____

B. the reducing agent is _____

C. the substance that is reduced is _____

D. the oxidizing agent is _____

Response/Marking Scheme

A. glucose (or carbon and hydrogen) 1
B. glucose 1
C. oxygen 1
D. oxygen 1

Maximum: 4

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Oxidation/Reduction
CURRICULAR EMPHASIS: Solid Foundations
KEYWORDS: oxidation reduction

INSTRUMENT CODE: B011KcSA.03
GUIDELINE OBJECTIVE CODE: 11Kc 21Ke
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

Guideline Objective

The student will be expected to identify and describe examples of oxidation and reduction reactions that occur in living organisms.

Item Focus

The student should be able to identify the reactants of a chemical equation in terms of oxidation-reduction.

Item

With reference to the following equation,

$Fe + Cl_2 \rightarrow Fe^{2+} + 2Cl^-$

A what is being oxidized?

B what is being reduced?

C what is the oxidizing agent?

D what is the reducing agent?

Response/Marking Scheme

A iron	1
B chlorine	1
C chlorine	1
D iron	1
Maximum:	4

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Hydrogen Bonds
CURRICULAR EMPHASIS: Solid Foundations
KEYWORDS: bonds

INSTRUMENT CODE: B011KdMC.01
GUIDELINE OBJECTIVE CODE: 11Kd
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.3
DIFFICULTY LEVEL: M
TIME ALLOCATION:

Guideline Objective

The student will be expected to describe the formation of the following bonds between atoms: ionic, covalent, polar covalent and hydrogen.

Item Focus

The student should be able to identify the properties of hydrogen bonds.

Item

Three of the following are characteristics of hydrogen bonds.

I They are weaker than covalent bonds.
II They play a role in keeping water molecules together.
III They are stronger than ionic bonds.
IV They are responsible for the relatively high boiling point of water.
V They are responsible for the surface tension properties of water.

Which of the following groupings is correct?

☐ A. I, II, and III

☐ B. I, II, and V

☐ C. II, III, and V

☐ D. II, III, and IV

☐ E. I, III, and V

Response/Marking Scheme

Correct response: B

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Chemical Bonding
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KdMC.02
GUIDELINE OBJECTIVE CODE: 11Kd
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: covalent bond

Guideline Objective

The student will be expected to describe the formation of the following bonds between atoms: ionic, covalent, polar covalent and hydrogen.

Item Focus

The student should be able to identify the type of chemical bond that would form between two atoms under specified conditions.

Item

If atoms of two different elements possessing similar electronegativities are brought together and conditions favour a reaction, which type of chemical bond is likely to form?

- [ ] A. non-polar covalent bond
- [ ] B. ionic bond
- [ ] C. hydrogen bond
- [ ] D. polar covalent bond
- [ ] E. Van der Waal's force

Response/Marking Scheme

Correct response: A

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Basic Chemical Concepts
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KdMC.03
GUIDELINE OBJECTIVE CODE: 11Kd
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: covalent bond

Guideline Objective

The student will be expected to describe the formation of the following bonds between atoms: ionic, covalent, polar covalent and hydrogen.

Item Focus

The student should be able to identify the concept of the number of electrons involved in a covalent bond.

Item

What is the number of electrons involved in each covalent bond?

- [ ] A. 0
- [ ] B. 1
- [ ] C. 2
- [ ] D. 3
- [ ] E. 4

Response/Marking Scheme

Correct response: C

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Chemical Bonding
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KdMC.04
GUIDELINE OBJECTIVE CODE: 11Kd
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.6
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: ionic bond

Guideline Objective

The student will be expected to describe the formation of the following bonds between atoms: ionic, covalent, polar covalent and hydrogen.

Item Focus

The student should be able to identify common types of chemical bonds.

Item

A transfer of electrons from one atom to another results in a bond that is

- [ ] A. covalent.
- [ ] B. polyvalent.
- [ ] C. a peptide.
- [ ] D. isotopic.
- [ ] E. ionic.

Response/Marking Scheme

Correct response: E

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Chemical Bonding
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KdMC.05
GUIDELINE OBJECTIVE CODE: 11Kd
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: covalent bond

Guideline Objective

The student will be expected to describe the formation of the following bonds between atoms: ionic, covalent, polar covalent and hydrogen.

Item Focus

The student should be able to identify basic chemical terms and their meanings.

Item

The C–H bond is a very important chemical bond, present in many biochemical molecules. The bond could be described as:

☐ A. a strong ionic bond.

☐ B. a covalent bond.

☐ C. a hydrogen bond.

☐ D. both ionic and covalent.

☐ E. a weak ionic bond.

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Chemical Bonding
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KdMC.06
GUIDELINE OBJECTIVE CODE: 11Kd
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: covalent bond

Guideline Objective

The student will be expected to describe the formation of the following bonds between atoms: ionic, covalent, polar covalent and hydrogen.

Item Focus

The student should be able to identify the conditions under which a covalent bond is formed.

Item

A covalent bond is formed when one atom

- [ ] A. donates a pair of electrons to another atom.
- [ ] B. shares protons with another atom.
- [ ] C. attracts an oppositely charged particle.
- [ ] D. shares electrons with another atom.
- [ ] E. receives a pair of electrons from another atom.

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Chemical Bonding
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KdMC.07
GUIDELINE OBJECTIVE CODE: 11Kd
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: covalent bond

Guideline Objective

The student will be expected to describe the formation of the following bonds between atoms: ionic, covalent, polar covalent and hydrogen.

Item Focus

The student should be able to identify the name of a bond from its description.

Item

A bond formed between a carbon atom and a hydrogen atom is called

☐ A. a double covalent bond.

☐ B. an ionic bond.

☐ C. a metallic bond.

☐ D. a single covalent bond.

☐ E. a hydrogen bond.

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Chemical Bonding
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KdMC.08
GUIDELINE OBJECTIVE CODE: 11Kd
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: disulfide bond

Guideline Objective

The student will be expected to describe the formation of the following bonds between atoms: ionic, covalent, polar covalent and hydrogen.

Item Focus

The student should be able to account for the shape of enzyme molecules.

Item

The STRONGEST bonds involved in maintaining the shape of enzyme molecules are

- [ ] A. hydrophobic bonds.
- [ ] B. hydrogen bonds.
- [ ] C. ionic interactions.
- [ ] D. dipole - dipole interactions.
- [ ] E. covalent (disulfide) bonds.

Response/Marking Scheme

Correct response: E

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Chemical Bonding
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KdER.01
GUIDELINE OBJECTIVE CODE: 11Kd
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: hydrogen bond covalent bond

Guideline Objective

The student will be expected to describe the formation of the following bonds between atoms: ionic, covalent, polar covalent and hydrogen.

Item Focus

The student should be able to define different types of bonds, and give an example of each.

Item

Explain the following terms, and for each, give an example.

A. hydrogen bond

B. covalent bond

Response/Marking Scheme

A. A hydrogen bond is a weak,	1
usually intramolecular attraction	1
between a positively polar hydrogen of	2
one side group with a negatively polar oxygen or nitrogen of	3
another side group. Adjacent water molecules are attracted to one another	1
by hydrogen bonds.	
Possible:	8
Maximum:	6
B. A covalent bond is a relatively strong	1
chemical bond in which an electron pair	1
is shared by two atoms, filling the	1
outer electron energy levels of both	1
at the same time. Carbon forms covalent	1
bonds in a multitude of organic compounds	1
such as methane, sugars, and lipids.	
Possible:	6
Maximum:	4
Total:	10

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Bond Energy
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KeMC.01
GUIDELINE OBJECTIVE CODE: 11Ke 21Kh
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: free energy exergonic reaction

Guideline Objective

The student will be expected to explain the concept of bond energy and use this concept to account for exergonic and endergonic chemical reactions.

Item Focus

The student should be able to identify the term, exergonic reaction, from a description of the energy relationships involved in the reaction.

Item

A chemical reaction during which free energy is released is called

- [ ] A. an endothermic reaction.
- [ ] B. an exergonic reaction.
- [ ] C. a nuclear reaction.
- [ ] D. an isothermic reaction.
- [ ] E. an endergonic reaction.

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Chemical Bonds
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KeER.01
GUIDELINE OBJECTIVE CODE: 11Ke
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, A.8, A.9
DIFFICULTY LEVEL: H
TIME ALLOCATION:

KEYWORDS: bond energy

Guideline Objective

The student will be expected to explain the concept of bond energy and use this concept to account for exergonic and endergonic chemical reactions.

Item Focus

Same as above.

Item

Explain the meaning of the term "bond energy" and explain how bond energies can be used to predict the outcome of chemical reactions.

Response/Marking Scheme

Bond energy is the quantity of energy theoretically required to break one	1
mole of bonds between atoms.	1
The concept of bond energy can be used to predict whether a proposed reaction will be exergonic or endergonic	1
but cannot predict entropy changes.	1
If the sum of the bond energies of bonds ruptured in a reaction (R)	1
is compared to the sum of the bond energies of the bonds formed in the reaction (P)	1
then the reaction is exergonic if P>R	1
and endergonic if R>P.	1
Possible:	8
Maximum:	5

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Chemical Reactions
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KeER.02
GUIDELINE OBJECTIVE CODE: 11Ke 21Kd 31Kg

INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, A.5, A.8, A.9, A.11, D.3
DIFFICULTY LEVEL: H
TIME ALLOCATION:

KEYWORDS: photosynthesis graphical analysis

Guideline Objective

The student will be expected to explain the concept of bond energy and use this concept to account for exergonic and endergonic chemical reactions.

Item Focus

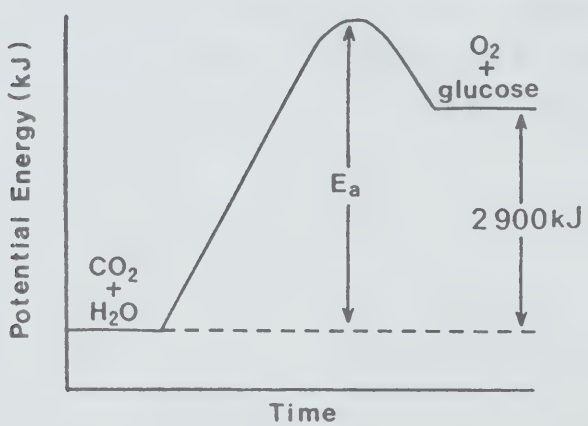
The student should be able to interpret a graph of potential energy relationships during photosynthesis.

Item

Refer to Figure 1K.12.

Figure 1K.12 is a graph representing the potential energy relationships during photosynthesis. Describe the events of photosynthesis in terms of the energy involved in the process. Begin with the equation for photosynthesis.

ENERGY RELATIONSHIPS



Response/Marking Scheme

The general equation for photosynthesis is $6CO_2 + 12H_2O + 2900kJ \rightarrow 6O_2 + C_6H_{12}O_6 + 6H_2O$

The Figure represents an endergonic (anabolic) reaction. 1

An endergonic reaction is one in which more energy is absorbed than released (the products contain more energy than the reactants). 1

Energy input comes from the sunlight, 1

which splits the water molecule and makes possible the fixation of carbon dioxide. 1

Both water and carbon dioxide are molecules with little free energy, and with considerable entropy. 1

Some of the energy captured in the light-dependent reactions is used as activation energy (E_a) for the formation of glucose in the light-independent reactions. 2

The product, glucose, has approximately 2 900 kJ of energy. 1

This molecule has considerable free energy (energy available to do work), and relatively low entropy. 2

Possible: 12

Maximum: 8

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B011KeER.03
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 11Ke
UNIT NUMBER: 01	INSTRUMENT TYPE: ER
UNIT NAME: CHEMICAL BASIS OF LIFE	KLOPFER: A.1, A.2, A.3, A.5, A.8, A.9, A.11, D.3
TOPIC: Chemical Reactions	DIFFICULTY LEVEL: H
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:

KEYWORDS: cellular respiration graphical analysis

Guideline Objective

The student will be expected to explain the concept of bond energy and use this concept to account for exergonic and endergonic chemical reactions.

Item Focus

The student should be able to interpret a graph of the potential energy relationships involved in cellular respiration.

Item

Refer to Figure 1K.13.

ENERGY RELATIONSHIPS

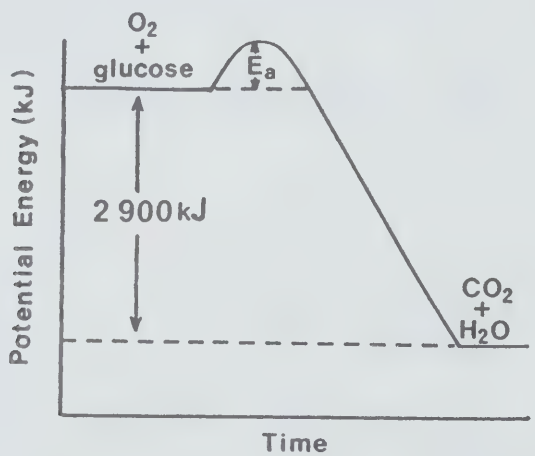


Figure 1K.13 is a graph of the potential energy relationships involved in cellular respiration.

In terms of energy, describe the events of cellular respiration illustrated by the graph. Begin with the balanced chemical equation for the process.

Response/Marking Scheme

The equation for cellular respiration is

$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_20 + 2900kJ$ 2

The graph illustrates a catabolic (exergonic) reaction. 1

An exergonic reaction releases more energy than it absorbs. 1

(The products have less energy than the reactants.)

The glucose molecule has more free energy and less entropy than does carbon dioxide and water. 1

Hence the reaction releases about 2 900 kJ of energy. 1

There must be a small amount of activation energy (E_a) added to the reactants by molecular activity to begin the breakdown of the bonds in glucose. 1

This is done by phosphorylating glucose using ATP. 1

The products, carbon dioxide and water, have higher entropy and lower free energy than the glucose. 2

Possible: 10

Maximum: 7

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B011KeER.04
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 11Ke
UNIT NUMBER: 01	INSTRUMENT TYPE: ER
UNIT NAME: CHEMICAL BASIS OF LIFE	KLOPFER: A.1, A.2, A.3, A.5, A.8, A.9, A.11, D.3
TOPIC: Chemical Reactions	DIFFICULTY LEVEL: H
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:
KEYWORDS: photosynthesis cellular respiration	

Guideline Objective

The student will be expected to explain the concept of bond energy and use this concept to account for exergonic and endergonic chemical reactions.

Item Focus

The student should be able to explain and graphically illustrate the energy relationships between the reactants and the products during photosynthesis and cellular respiration.

Item

Describe and explain the events of photosynthesis and cellular respiration with respect to energy relationships of the reactants and the products. Draw graphs to represent the changes in potential energy during each of the reactions.

Response/Marking Scheme

The general equation for photosynthesis is

$6CO_2 + 12H_2O + 2900kJ \rightarrow 6O_2 + C_6H_{12}O_6 + 6H_2O$ 2

The Figure represents an endergonic (anabolic) reaction. 1

An endergonic reaction is one in which more energy is absorbed than released (the products contain more energy than the reactants). 1

Energy input comes from the sunlight, 1

which splits the water molecule and makes possible the fixation of carbon dioxide. 1

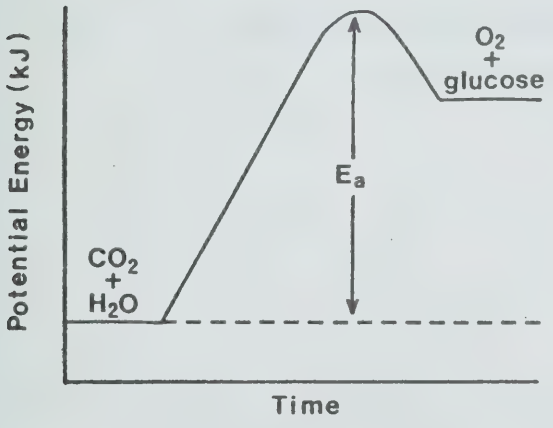
Both water and carbon dioxide are molecules with little free energy, and with considerable entropy. 1

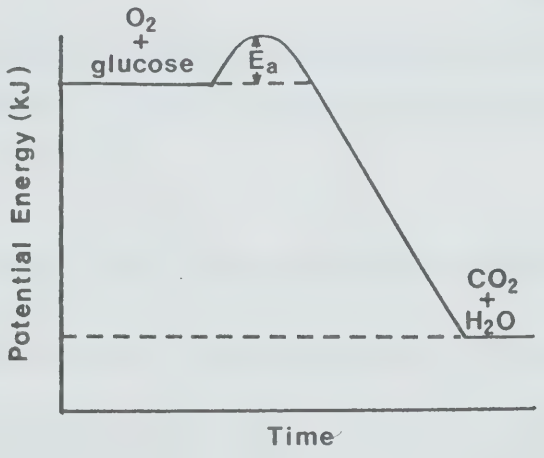
Some of the energy captured in the light-dependent reactions is used as activation energy (E_a) for the formation of glucose in the light-independent reactions. 2

The product, glucose, has approximately 2 900 kJ of energy more than the reactants. 1

This molecule has considerable free energy (energy available to do work), and relatively low entropy. 2

Potential energy graphs: (3 marks each) 6





The equation for cellular respiration is

$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + 2900kJ$ 2

The graph illustrates a catabolic (exergonic) reaction. 1

An exergonic reaction releases more energy than it absorbs. 1

(The products have less energy than the reactants.)

The glucose molecule has more free energy and less entropy than does carbon dioxide and water. 1

Hence the reaction releases about 2 900 kJ of energy. 1

There must be a small amount of activation energy (E_a) added to the reactants by molecular activity to begin the breakdown of the bonds in glucose. 1

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B011KhER.04
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 11Kh
UNIT NUMBER: 01	INSTRUMENT TYPE: ER
UNIT NAME: CHEMICAL BASIS OF LIFE	KLOPFER: A.1, A.2, A.3, A.6, A.7, A.8, C.1, C.2
TOPIC: Protein Structure/Function	DIFFICULTY LEVEL: H
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:

KEYWORDS: starch cellulose enzyme

Guideline Objective

The student will be expected to describe, in general terms, the components of protein structure and the importance of this structure in the role of such biologically active proteins as enzymes and hormones.

Item Focus

The student should be able to use the lock and key model of enzyme specificity to account for the action of the enzyme salivary amylase (ptyalin) on starch but not on cellulose.

Item

A student investigated the action of saliva on a suspension of starch and on a suspension of cellulose by setting up the following test tubes:

1. 2 mL of starch suspension + 2 mL of saliva
2. 2 mL of cellulose suspension + 2 mL of saliva

The pH of each test tube was 7.5. The test tubes were maintained in a water bath at 37°C for 10 min. A Benedict's test was then carried out on the contents of each test tube. The following observations were recorded:

1. brick red
2. blue (no change)

Use the lock and key model to explain why the starch was changed, but not the cellulose. Refer to the molecular structure of starch and cellulose in your answer.

This is done by phosphorylating glucose using ATP. 1

The products, carbon dioxide and water, have higher entropy and lower free energy than the glucose. 2

Possible: 28

Maximum: 20

Quality: 2

Total: 22

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Chemical Reactions
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KeER.05
GUIDELINE OBJECTIVE CODE: 11Ke
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.3, A.5, A.8. A.9
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: photosynthesis

Guideline Objective

The student will be expected to explain the concept of bond energy and use this concept to account for exergonic and endergonic chemical reactions.

Item Focus

The student should be able to explain the chemical reason for molecules differing in free energy, and be able to state the significance of such phenomena to life.

Item

The chemical reactions of photosynthesis result in products such as glucose with considerably more energy and considerably more free energy than the reactants.

A. What is the primary source of this extra energy?

B. What is the chemical reason that the energy of one compound is considerably more than that of others?

C. What is the significance of this phenomenon for life?

Response/Marking Scheme

A. The energy comes from radiant energy from the sun. 1

B. The reason for greater free (available) energy in compounds is related to the molecular configuration 1

of the compound - the number, type, and arrangement of chemical bonds holding the atoms of the molecule 3

together. The energy required to break a chemical bond is referred to as bond energy. In some molecules, the net result of breaking a bond, with the creation of new bonds in accompanying intermediate 2

reactions, gives rise to a release of available energy.

C. Energy is needed for all life functions. The storage of the radiant energy in the bond energy of large molecules makes it available at any time. 2

Possible: 9

Maximum: 7

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B011KeSA.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 11Ke
UNIT NUMBER: 01	INSTRUMENT TYPE: SA
UNIT NAME: CHEMICAL BASIS OF LIFE	KLOPFER: A.1, A.2, A.3, A.5, A.8. A.9, A.11, D.3
TOPIC: Chemical Reactions	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:

KEYWORDS: exergonic, cellular respiration, energy of activation, graphical analysis

Guideline Objective

The student will be expected to explain the concept of bond energy and use this concept to account for exergonic and endergonic chemical reactions.

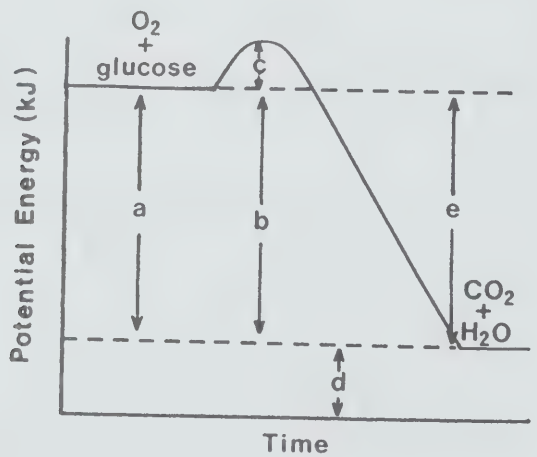
Item Focus

The student should be able to interpret a potential energy graph of an exergonic reaction.

Item

Refer to Figure 1K.14.

ENERGY RELATIONSHIPS



With respect to the potential energy diagram shown in Figure 1K.14,

A. What type of reaction is shown?

B. Compare the free energy of the reactants to that of the products.

C. Which letter represents the energy of activation?

D. Name a process where this type of reaction occurs.

Response/Marking Scheme

A. exergonic 1

B. the free energy of the reactants is greater than that of the products. 1

C. Letter **c** on the diagram represents E_a. 1

D. Cellular respiration. 1

Maximum: 4

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Chemical Reactions
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KeSA.02
GUIDELINE OBJECTIVE CODE: 11Ke
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.3, A.5, A.8. A.9, A.11,
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: energy graphical analysis

Guideline Objective

The student will be expected to explain the concept of bond energy and use this concept to account for exergonic and endergonic chemical reactions.

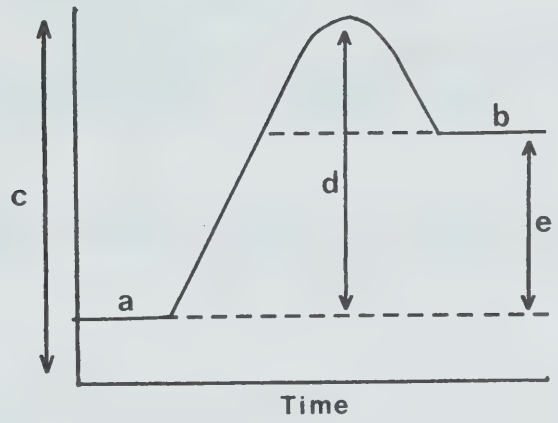
Item Focus

The student should be able to label a potential energy graph of an endergonic reaction.

Item

Refer to Figure 1K.15.

ENERGY RELATIONSHIPS



What do the following parts of the graph represent?

a.

b.

c.

d.

e.

Response/Marking Scheme

a. energy of the reactants	1
b. energy of the products	1
c. potential energy	1
d. energy of activation	1
e. free energy	1
Maximum:	5

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B011KeSA.03
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 11Ke
UNIT NUMBER: 01	INSTRUMENT TYPE: SA
UNIT NAME: CHEMICAL BASIS OF LIFE	KLOPFER: A.1, A.2, A.3, A.5, A.8. A.9, A.11, D.3
TOPIC: Chemical Reactions	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:

KEYWORDS: photosynthesis energy of activation graphical analysis

Guideline Objective

The student will be expected to explain the concept of bond energy and use this concept to account for exergonic and endergonic chemical reactions.

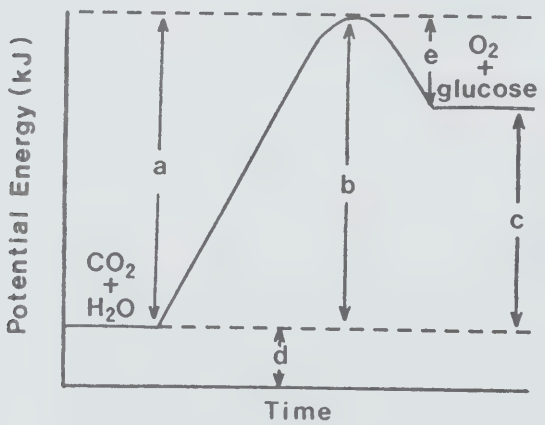
Item Focus

The student should be able to interpret a potential energy graph of an endergonic reaction.

Item

Refer to Figure 1K.16.

ENERGY RELATIONSHIPS



With respect to the potential energy diagram shown in Figure 1K.16,

A. What type of reaction is shown?

B. Compare the free energy of the reactants to that of the products.

C. What letter represents the energy of activation?

D. Name a process where this type of reaction occurs.

Response/Marking Scheme

A. endergonic	1
B. the free energy of the reactants is much less than that of the products.	1
C. Letter **a** on the diagram represents E_a.	1
D. Photosynthesis	1
Maximum:	4

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Chemical Reactions
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B011KeSA.04
GUIDELINE OBJECTIVE CODE: 11Ke
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.3, A.5, A.8. A.9, A.11, D.3
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: energy

Guideline Objective

The student will be expected to explain the concept of bond energy and use this concept to account for exergonic and endergonic chemical reactions.

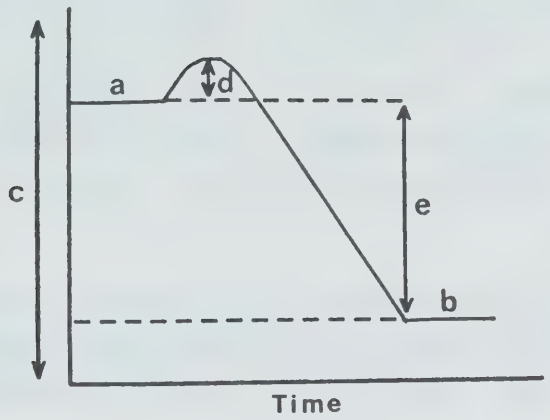
Item Focus

The student should be able to label a potential energy graph of an exergonic reaction.

Item

Refer to Figure 1K.17.

ENERGY RELATIONSHIPS



What do the following parts of the graph represent?

a.

b.

c.

d.

e.

Response/Marking Scheme

a. energy of the reactants	1
b. energy of the products	1
c. potential energy	1
d. energy of activation	1
e. free energy	1
Maximum:	5

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Functional Groups
CURRICULAR EMPHASIS: Solid Foundations
KEYWORDS: monosaccharide

INSTRUMENT CODE: B011KfMC.01
GUIDELINE OBJECTIVE CODE: 11Kf
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

Guideline Objective

The student will be expected to describe, using representative examples and structural formulas, the general structural features, the key subgroups, functional related linkages, and the main functions in living organisms, of carbohydrates, lipids, proteins, and nucleic acids.

Item Focus

The student should be able to identify the functional groups found in a monosaccharide.

Item

Which functional groups would be found in monosaccharides?

- [ ] A. sulfhydryl and hydroxyl
- [ ] B. carbonyl and carboxyl
- [ ] C. amino and carboxyl
- [ ] D. hydroxyl and glycosidic
- [ ] E. hydroxyl and carbonyl

Response/Marking Scheme

Correct response: E

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Polymers
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KfMC.02
GUIDELINE OBJECTIVE CODE: 11Kf
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS:

Guideline Objective

The student will be expected to describe, using representative examples and structural formulas, the general structural features, the key subgroups, functional related linkages, and the main functions in living organisms, of carbohydrates, lipids, proteins, and nucleic acids.

Item Focus

The student should be able to identify substances that are polymers.

Item

Which of the following is NOT a polymer?

- [ ] A. fat
- [ ] B. protein
- [ ] C. starch
- [ ] D. RNA
- [ ] E. cellulose

Response/Marking Scheme

Correct response: A

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Biologically Important Molecules
CURRICULAR EMPHASIS: Solid Foundations
KEYWORDS: protein

INSTRUMENT CODE: B011KfMC.03
GUIDELINE OBJECTIVE CODE: 11Kf
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.6
DIFFICULTY LEVEL: L
TIME ALLOCATION:

Guideline Objective

The student will be expected to describe, using representative examples and structural formulas, the general structural features, the key subgroups, functional related linkages, and the main functions in living organisms, of carbohydrates, lipids, proteins, and nucleic acids.

Item Focus

The student should be able to identify the structure of a protein.

Item

Which one of the following important biological compounds contains the element, nitrogen?

- [ ] A. protein.
- [ ] B. starch.
- [ ] C. glycerol.
- [ ] D. sugar.
- [ ] E. fatty acid.

Response/Marking Scheme

Correct response: A

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Biologically Important Molecules
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KfMC.04
GUIDELINE OBJECTIVE CODE: 11Kf
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: amino acid

Guideline Objective

The student will be expected to describe, using representative examples and structural formulas, the general structural features, the key subgroups, functional related linkages, and the main functions in living organisms, of carbohydrates, lipids, proteins, and nucleic acids.

Item Focus

The student should be able to identify the components of amino acids.

Item

The four chemical elements that make up all amino acid molecules are: carbon, hydrogen,

- [ ] A. oxygen and phosphorus.
- [ ] B. oxygen and nitrogen.
- [ ] C. oxygen and sulphur.
- [ ] D. nitrogen and phosphorus.
- [ ] E. nitogen and sulphur.

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Biologically Important Molecules
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KfMC.05
GUIDELINE OBJECTIVE CODE: 11Kf
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.11
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: amino acid

Guideline Objective

The student will be expected to describe, using representative examples and structural formulas, the general structural features, the key subgroups, functional related linkages, and the main functions in living organisms, of carbohydrates, lipids, proteins, and nucleic acids.

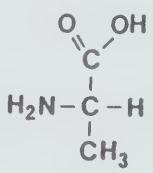
Item Focus

The student should be able to identify the monomers of which proteins are composed.

Item

Refer to Figure 1K.18.

A STRUCTURAL FORMULA



The formula represented in Figure 1K.18 is

- ☐ A. a protein.
- ☐ B. a peptide.
- ☐ C. a sugar.
- ☐ D. an amino acid.
- ☐ E. a lipid.

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Biologically Important Molecules
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KfMC.06
GUIDELINE OBJECTIVE CODE: 11Kf
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: protein

Guideline Objective

The student will be expected to describe, using representative examples and structural formulas, the general structural features, the key subgroups, functional related linkages, and the main functions in living organisms, of carbohydrates, lipids, proteins, and nucleic acids.

Item Focus

The student should be able to identify components of biologically important molecules, such as proteins.

Item

A substance that, when digested, yields a mixture of amino acids is a

- [ ] A. fat.
- [ ] B. protein.
- [ ] C. sugar.
- [ ] D. nucleotide.
- [ ] E. carbohydrate.

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Carbohydrates
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KfMC.07
GUIDELINE OBJECTIVE CODE: 11Kf
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: monosaccharide

Guideline Objective

The student will be expected to describe, using representative examples and structural formulas, the general structural features, the key subgroups, functional related linkages, and the main functions in living organisms, of carbohydrates, lipids, proteins, and nucleic acids.

Item Focus

The student should be able to identify terms used for specific monomers and polymers.

Item

An example of a monosaccharide is

- ☐ A. sucrose.
- ☐ B. glucose.
- ☐ C. cellulose.
- ☐ D. glycogen.
- ☐ E. maltose.

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Carbohydrate Structure
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KfMC.08
GUIDELINE OBJECTIVE CODE: 11Kf
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.10
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: polysaccharide

Guideline Objective

The student will be expected to describe, using representative examples and structural formulas, the general structural features, the key subgroups, functional related linkages, and the main functions in living organisms, of carbohydrates, lipids, proteins, and nucleic acids.

Item Focus

The student should be able to identify an unknown substance as a polysaccharide.

Item

Refer to Figure 1K.19.

A REPEATING POLYMER

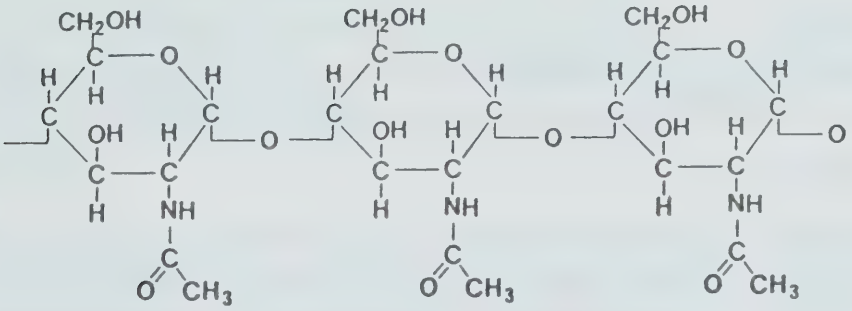


Figure 1K.19 shows a small portion of a repeating structure found in the exoskeleton (cuticle) of an insect. Chemically speaking, it could best be described as:

- [ ] A. fat.
- [ ] B. polypeptide.
- [ ] C. nucleic acid.
- [ ] D. polysaccharide.
- [ ] E. wax.

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Linkages
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KfMC.09
GUIDELINE OBJECTIVE CODE: 11Kf
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.11
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: ester linkage

Guideline Objective

The student will be expected to describe, using representative examples and structural formulas, the general structural features, the key subgroups, functional related linkages, and the main functions in living organisms, of carbohydrates, lipids, proteins, and nucleic acids.

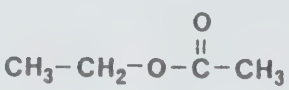
Item Focus

The student should be able to identify an ester linkage shown in a structural formula.

Item

Refer to Figure 1K.20.

A MOLECULAR FORMULA



The linkage represented by the structural formula of the molecule shown in Figure 1K.20 is

- [ ] A. an ether linkage.
- [ ] B. an ester linkage.
- [ ] C. a peptide linkage.
- [ ] D. an amide linkage.
- [ ] E. a glycosidic linkage.

Response/Marking Scheme

Correct response: B

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B011KfMC.10
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 11Kf
UNIT NUMBER: 01	INSTRUMENT TYPE: MC
UNIT NAME: CHEMICAL BASIS OF LIFE	KLOPFER: A.1, A.2, A.3, C.2, D.3, D.4, D.6
TOPIC: Synthesis of Glycogen	DIFFICULTY LEVEL: H
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:
KEYWORDS: enzyme graphical analysis	

Guideline Objective

The student will be expected to describe, using representative examples and structural formulas, the general structural features, the key subgroups, functional related linkages, and the main functions in living organisms, of carbohydrates, lipids, proteins, and nucleic acids.

Item Focus

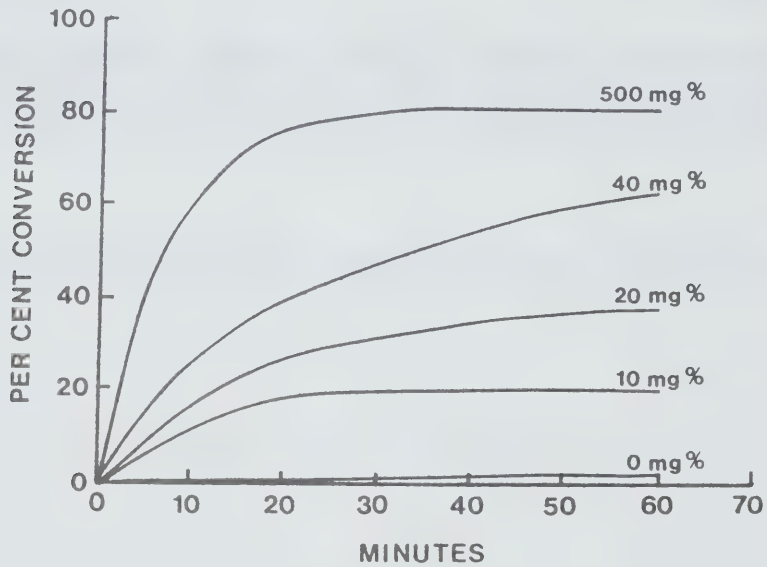
The student should be able to interpret graphs that relate to metabolism within cells.

Item

Refer to Figure 1K.21.

A preparation of ground-up muscle was subdivided into 5 equal portions. In each portion, the same amount of glucose-1-phosphate was added and the rate at which the enzymes of the ground muscle converted the glucose-1-phosphate into glycogen was measured. A different quantity of pre-formed glycogen was added to each of the 5 portions and the results are shown graphically in Figure 1K.21.

SYNTHESIS OF GLYCOGEN



Which of the following statements is consistent with the observations displayed on the graphs?

☐ A. The glycogen-synthesizing enzyme is subject to end-product inhibition.

☐ B. Doubling the concentration of glycogen doubles the quantity of glucose-1-phosphate ultimately converted into glycogen.

☐ C. Glycogen acts as a template (pattern) for its own synthesis.

☐ D. Glycogen cannot be synthesized in the absence of preformed glycogen.

☐ E. Inorganic phosphate is a by-product of the reaction.

Response/Marking Scheme

Correct response: C

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Structure of RNA
CURRICULAR EMPHASIS: Solid Foundations
KEYWORDS: mRNA nucleic acid

INSTRUMENT CODE: B011KfMC.11
GUIDELINE OBJECTIVE CODE: 11Kf
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2
DIFFICULTY LEVEL: L
TIME ALLOCATION:

Guideline Objective

The student will be expected to describe, using representative examples and structural formulas, the general structural features, the key subgroups, functional related linkages, and the main functions in living organisms, of carbohydrates, lipids, proteins, and nucleic acids.

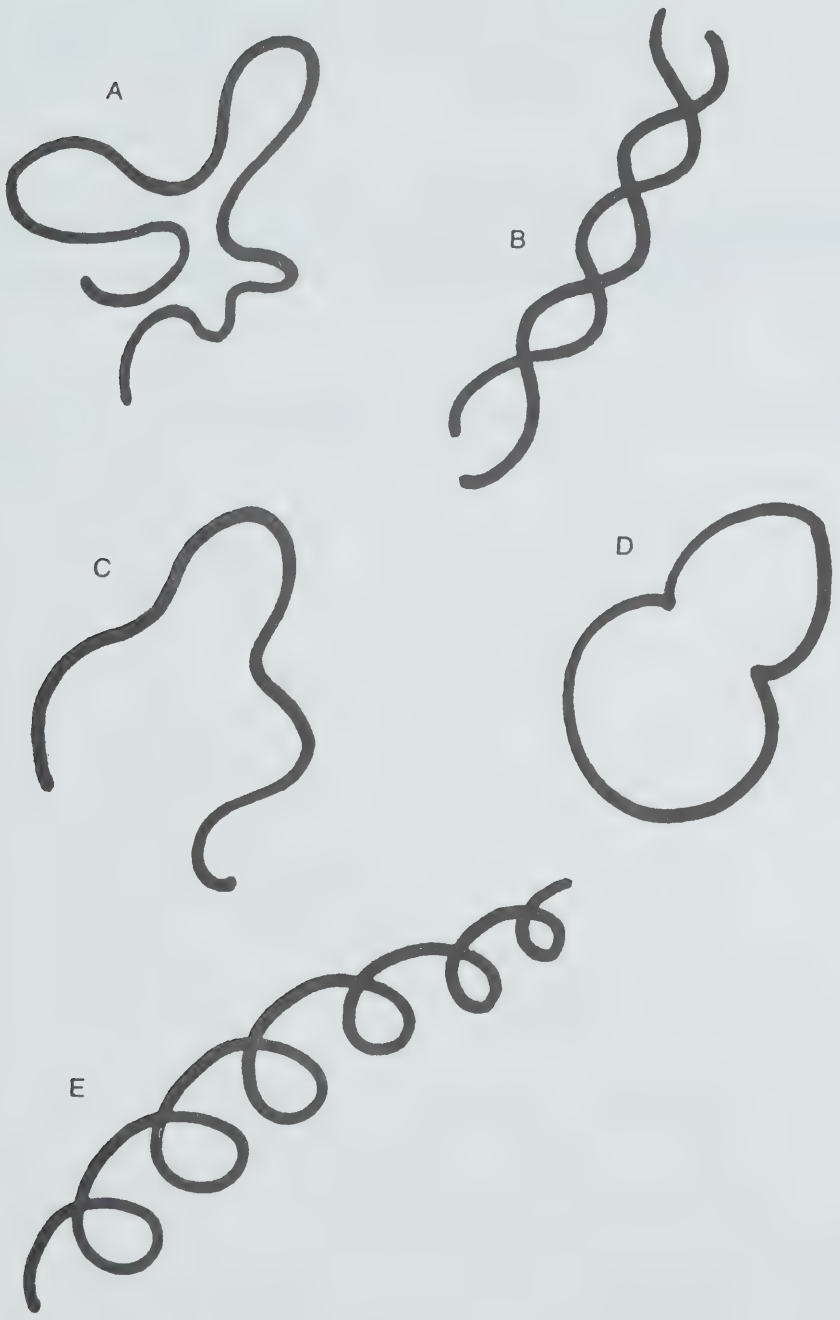
Item Focus

The student should be able to recognize the standard textbook depictions of vital molecules.

Item

Refer to Figure 1K.22.

THE STRUCTURES OF NUCLEIC ACIDS



Which diagram best represents the structure of mRNA?

☐ A.

☐ B.

☐ C.

☐ D.

☐ E.

Response/Marking Scheme

Correct response: C

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Structure of DNA
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KfMC.12
GUIDELINE OBJECTIVE CODE: 11Kf
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: DNA nucleic acid

Guideline Objective

The student will be expected to describe, using representative examples and structural formulas, the general structural features, the key subgroups, functional related linkages, and the main functions in living organisms, of carbohydrates, lipids, proteins, and nucleic acids.

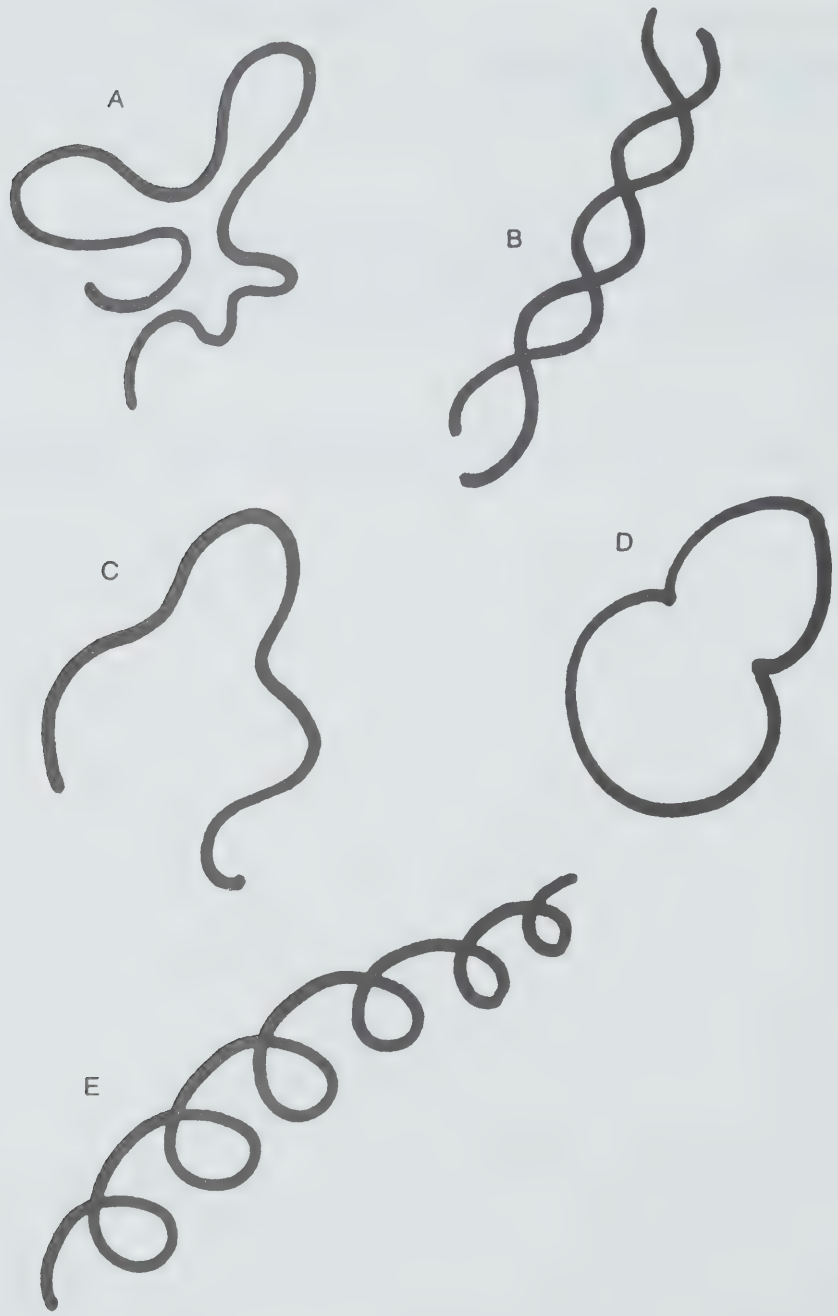
Item Focus

The student should be able to recognize the standard text-book representations of vital macromolecules.

Item

Refer to Figure 1K.22 at this point.

THE STRUCTURES OF NUCLEIC ACIDS



Which diagram in Figure 1K.22 is the best representation of the structure of DNA?

- [ ] A.
- [ ] B.
- [ ] C.
- [ ] D.
- [ ] E.

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Functional Groups and Linkages
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KfMC.13
GUIDELINE OBJECTIVE CODE: 11Kf
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: ester linkage

Guideline Objective

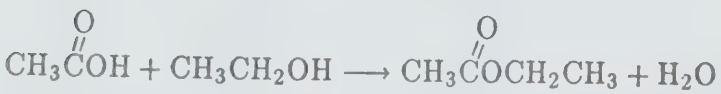
The student will be expected to describe, using representative examples and structural formulas, the general structural features, the key subgroups, functional related linkages, and the main functions in living organisms, of carbohydrates, lipids, proteins, and nucleic acids.

Item Focus

The student should be able to identify a specific type of linkage in the formula of a molecule, given the equation for its formation.

Item

Consider the following reaction:



What kind of linkage occurs in the first end-product shown?

- [ ] A. glycoside
- [ ] B. ester
- [ ] C. ether
- [ ] D. peptide
- [ ] E. aldehyde

Response/Marking Scheme

Correct response: B

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Biologically Important Molecules
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KfMC.15
GUIDELINE OBJECTIVE CODE: 11Kf
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: cellulose Golgi apparatus

Guideline Objective

The student will be expected to describe, using representative examples and structural formulas, the general structural features, the key subgroups, functional related linkages, and the main functions in living organisms, of carbohydrates, lipids, proteins, and nucleic acids.

Item Focus

The student should be able to identify the site where cellulose molecules are synthesized in plant cells.

Item

In plant cells, cellulose is synthesized within the

- [ ] A. cell wall.
- [ ] B. nucleus.
- [ ] C. chloroplast.
- [ ] D. mitochondrion.
- [ ] E. Golgi apparatus.

Response/Marking Scheme

Correct response: E

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Biologically Important Molecules
CURRICULAR EMPHASIS: Practical Applications

INSTRUMENT CODE: B011KfMC.16
GUIDELINE OBJECTIVE CODE: 11Kf
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: fats fatty acid lipid

Guideline Objective

The student will be expected to describe, using representative examples and structural formulas, the general structural features, the key subgroups, functional related linkages, and the main functions in living organisms, of carbohydrates, lipids, proteins, and nucleic acids.

Item Focus

The student should be able to identify the difference in structure of different lipids.

Item

When you open the door of a refrigerator, you may see a variety of foods that contain lipids, such as, butter, margarine, and milk. The lipids in these foods differ from one another in their

☐ A. glycerols.

☐ B. fatty acids.

☐ C. phosphates.

☐ D. hydrogen bonds.

☐ E. sodium stearates.

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Biologically Important Molecules
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KfMC.17
GUIDELINE OBJECTIVE CODE: 11Kf
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.11
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: carbohydrate

Guideline Objective

The student will be expected to describe, using representative examples and structural formulas, the general structural features, the key subgroups, functional related linkages, and the main functions in living organisms, of carbohydrates, lipids, proteins, and nucleic acids.

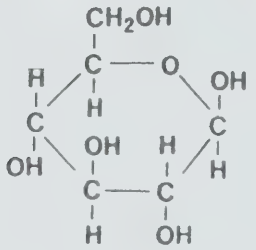
Item Focus

The student should be able to recognize the monomers of which carbohydrates are composed.

Item

Refer to Figure 1K.24.

A MOLECULAR FORMULA



The formula represented in Figure 1K.24 is

- [ ] A. a protein
- [ ] B. a peptide
- [ ] C. a carbohydrate
- [ ] D. an amino acid
- [ ] E. an isomer

Response/Marking Scheme

Correct response: C

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Nitrogen Metabolism
CURRICULAR EMPHASIS: Solid Foundations
KEYWORDS: protein

INSTRUMENT CODE: B011KfMC.18
GUIDELINE OBJECTIVE CODE: 11Kf
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

Guideline Objective

The student will be expected to describe, using representative examples and structural formulas, the general structural features, the key subgroups, functional related linkages, and the main functions in living organisms, of carbohydrates, lipids, proteins, and nucleic acids.

Item Focus

The student should be able to identify compounds with specific biological processes.

Item

Which one of the following compounds, when broken down during metabolism, CANNOT result in the production of urea?

- ☐ A. peptides.
- ☐ B. proteins.
- ☐ C. enzymes.
- ☐ D. amino acids.
- ☐ E. glucose.

Response/Marking Scheme

Correct response: E

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Polymers
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KfMC.19
GUIDELINE OBJECTIVE CODE: 11Kf
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: glycogen

Guideline Objective

The student will be expected to describe, using representative examples and structural formulas, the general structural features, the key subgroups, functional related linkages, and the main functions in living organisms, of carbohydrates, lipids, proteins, and nucleic acids.

Item Focus

The student should be able to identify the function of glycogen in an animal.

Item

The function of glycogen in an organism is

- [ ] A. to store glucose in plants.
- [ ] B. to increase osmotic pressure in cells.
- [ ] C. to keep glucose available yet osmotically inactive.
- [ ] D. to dilute the blood plasma.
- [ ] E. to synthesize proteins.

Response/Marking Scheme

Correct response: C

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Biologically Important Molecules
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KfMC.20
GUIDELINE OBJECTIVE CODE: 11Kf
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.6, A.10
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: carbohydrate fatty acid

Guideline Objective

The student will be expected to describe, using representative examples and structural formulas, the general structural features, the key subgroups, functional related linkages, and the main functions in living organisms, of carbohydrates, lipids, proteins, and nucleic acids.

Item Focus

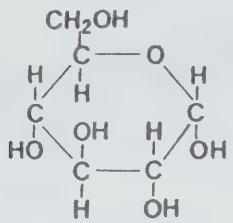
The student should be able to identify biologically important molecules that join with others to form larger molecules.

Item

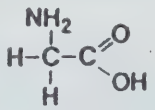
Refer to Figure 1K.25.

SOME STRUCTURAL FORMULAE

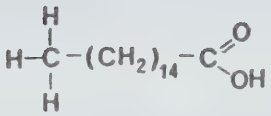
A.



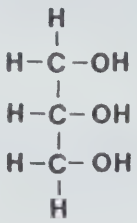
B.



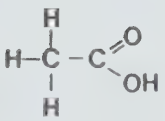
C.



D.



E.



1. Which compound forms the basis of disaccharides?
2. Which compound joins chemically with glycerol to form a lipid?
3. Which compound is the fundamental unit of cellulose?

Response/Marking Scheme

Correct responses:

1. A; 2. C; 3. A.

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Chemical Groups and Linkages
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KfMC.21
GUIDELINE OBJECTIVE CODE: 11Kf
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: ester linkage

Guideline Objective

The student will be expected to describe, using representative examples and structural formulas, the general structural features, the key subgroups, functional related linkages, and the main functions in living organisms, of carbohydrates, lipids, proteins, and nucleic acids.

Item Focus

The student should be able to identify the reactants that would have formed a specific type of linkage.

Item

When an ester linkage is formed, the reactants must have been

- [ ] A. two amino acids.
- [ ] B. two carboxylic acids.
- [ ] C. a carboxylic acid and an alcohol.
- [ ] D. two alcohols.
- [ ] E. a carboxylic acid and an amino acid.

Response/Marking Scheme

Correct response: C

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B011KfMC.23
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 11Kf
UNIT NUMBER: 01	INSTRUMENT TYPE: MC
UNIT NAME: CHEMICAL BASIS OF LIFE	KLOPFER: A1, A.2, A.3
	DIFFICULTY LEVEL: L
TOPIC: Functional Linkage	TIME ALLOCATION:
CURRICULAR EMPHASIS: Solid Foundations	
KEYWORDS: ether linkage	

Guideline Objective

The student will be expected to describe, using representative examples and structural formulas, the general structural features, the key subgroups, functional related linkages, and the main functions in living organisms, of carbohydrates, lipids, proteins, and nucleic acids.

Item Focus

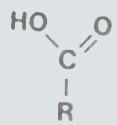
The student should be able to identify an ether linkage.

Item

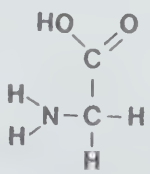
Refer to Figure 1K.26 to answer this question.

STRUCTURAL FORMULAE OF SOME COMPOUNDS

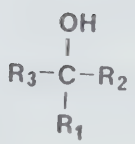
A.



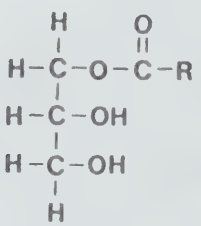
D.



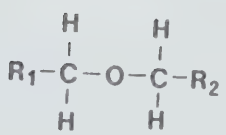
B.



E.



C.



Which of the molecules shown in Figure 1K.26 contains an ether linkage?

Response/Marking Scheme

Correct response: C

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Functional Linkage
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KfMC.24
GUIDELINE OBJECTIVE CODE: 11Kf
INSTRUMENT TYPE: AC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: ether linkage

Guideline Objective

The student will be expected to describe, using representative examples and structural formulas, the general structural features, the key subgroups, functional related linkages, and the main functions in living organisms, of carbohydrates, lipids, proteins, and nucleic acids.

Item Focus

The student should be able to identify the functional groups that react to produce an ether linkage.

Item

An ether linkage is formed between:

- [ ] A. two carboxyl groups.
- [ ] B. two hydroxyl groups.
- [ ] C. an hydroxyl group and a carboxyl group.
- [ ] D. two amino groups.
- [ ] E. an hydroxyl group and a methyl radical.

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Functional Linkages
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KfMC.25
GUIDELINE OBJECTIVE CODE: 11Kf
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: ester linkage

Guideline Objective

The student will be expected to describe, using representative examples and structural formulas, the general structural features, the key subgroups, functional related linkages, and the main functions in living organisms, of carbohydrates, lipids, proteins, and nucleic acids.

Item Focus

The student should be able to identify the linkage formed when an alcohol and an organic acid react.

Item

Refer to Figure 1K.27 at this point.

TWO MOLECULES

When the molecules shown in Figure 1K.27 undergo a dehydration synthesis (condensation) reaction, the linkage formed is

- [ ] A. a peptide.
- [ ] B. an aldehyde.
- [ ] C. a ketone.
- [ ] D. an ester.
- [ ] E. an ether.

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Functional Linkages
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KfMC.26
GUIDELINE OBJECTIVE CODE: 11Kf
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: ether linkage

Guideline Objective

The student will be expected to describe, using representative examples and structural formulas, the general structural features, the key subgroups, functional related linkages, and the main functions in living organisms, of carbohydrates, lipids, proteins, and nucleic acids.

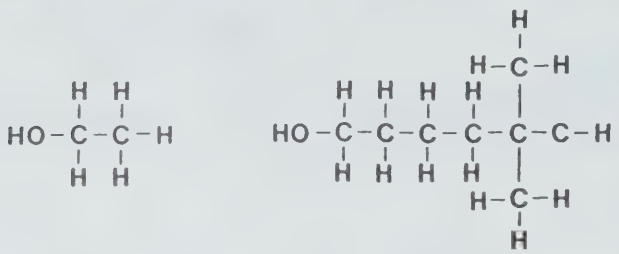
Item Focus

The student should be able to identify the linkage formed when two alcohols undergo condensation.

Item

Refer to Figure 1K.28 at this point.

TWO MOLECULES



When the molecules shown in Figure 1K.28 undergo a condensation reaction, the linkage formed is

- [ ] A. a peptide.
- [ ] B. an aldehyde.
- [ ] C. a ketone.
- [ ] D. an ester.
- [ ] E. an ether.

Response/Marking Scheme

Correct response: E

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Polymers
CURRICULAR EMPHASIS: Practical Applications

INSTRUMENT CODE: B011KfEE.01
GUIDELINE OBJECTIVE CODE: 11Kf
INSTRUMENT TYPE: EE
KLOPFER: A.1, A.3, A.8, A.10, F.2
DIFFICULTY LEVEL: H
TIME ALLOCATION:

KEYWORDS: glucose starch osmosis turgor

Guideline Objective

The student will be expected to describe, using representative examples and structural formulas, the general structural features, the key subgroups, functional related linkages, and the main functions in living organisms, of carbohydrates, lipids, proteins, and nucleic acids.

Item Focus

The student should be able to apply knowledge of the formation of the polymer starch to an everyday problem.

Item

A biology student, shopping at the supermarket, found two bins of corn-on-the-cob. Wanting to buy the freshest corn, the student applied a freshness test ("the greengrocer test") to ears of corn chosen at random from each bin. In this test, a kernel of corn is exposed on the ear, and the thumbnail is pressed firmly against it; the juice extruded is carefully observed.

In this case, a kernel from "Bin A" extruded a milky juice that emerged in a trickle; while a kernel from "Bin B" extruded a clear juice that emerged forcefully.

A. From which bin would the student select, in order to be sure of getting fresher corn?

B. Explain your answer in terms of the biological facts and processes you have learned in this course.

Response/Marking Scheme

A. The student would choose from "Bin B". 1

B. Corn stores energy reserves in the kernels. 1

These first appear as sweet monosaccharides, (glucose) 1

and disaccharides (sucrose), 1

but as the kernel matures, these are 1

converted to starch. This allows storage of 1

more energy in a polymer of 1

low osmotic activity, which is desirable to provide 1

the seed with energy in a form that can survive drying out to withstand extreme conditions. The maturation process occurs naturally, and also is stimulated when the corn ear is picked. 1

Kernels form "Bin B" had colourless sap, indicating 1

that their carbohydrate reserves were in the form of highly soluble mono- and disaccharides.

This was confirmed by the high turgor pressure, indicating 1

a high concentration of osmotically active particles. 1

Kernels from "Bin A", on the other hand, showed a milky juice, indicating insoluble starch, 1

and the trickle indicated low turgor pressure, the 1

result of low osmotic pressure. This would mean 1

that either the ears of corn had been picked a considerable time before, 1

or that they had been left to mature on the plant too long. 1

In either case, they would lack the sweet taste of fresh corn.

Possible: 18

Maximum: 10

Quality: 2

Total: 12

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Protein Structure and Function
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B011KfER.01
GUIDELINE OBJECTIVE CODE: 11Kf
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, A.10, D.2, F.1
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: amino acid protein secondary structure

Guideline Objective

The student will be expected to describe, using representative examples and structural formulas, the general structural features, the key subgroups, functional related linkages, and the main functions in living organisms, of carbohydrates, lipids, proteins, and nucleic acids.

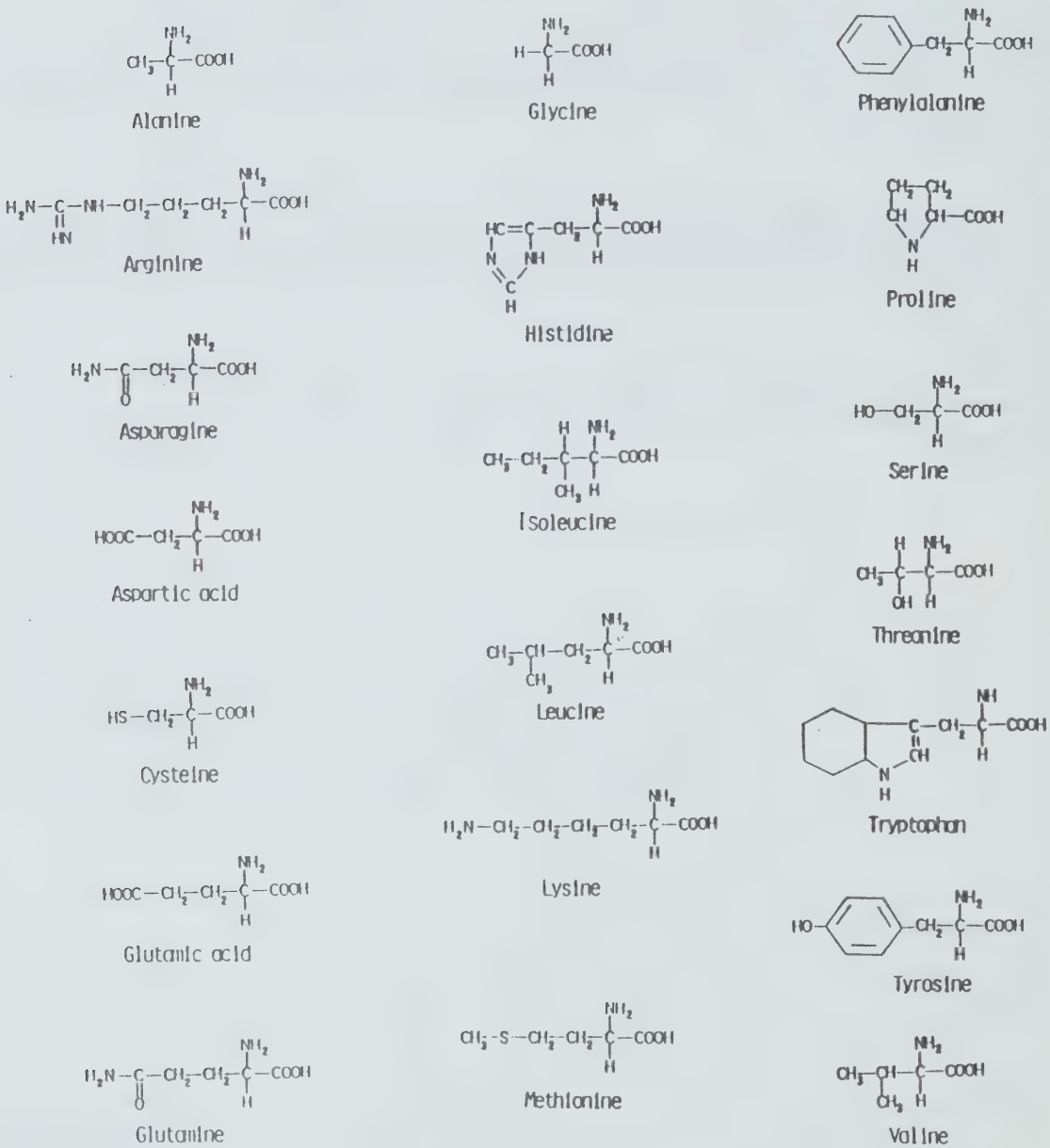
Item Focus

The student should be able to account for the secondary structure of a protein in terms of peptide bonding.

Item

Refer to Figure 1K.29.

AMINO ACIDS: STRUCTURAL FORMULAE



While it is often said that there are twenty amino acids commonly occurring in polypeptides and proteins, one of them differs from the others in such a way that we might say that there are nineteen amino acids and one imino acid.

A. Examine the structural formulae shown in Figure 1K.29, and name the one that is probably the imino acid.

B. What is the chemical difference between this compound, the imino acid, and an amino acid?

C. Predict and account for the effect of building this imino acid into the polypeptide chain upon its secondary structure.

Response/Marking Scheme

A. Proline 1

B. The nitrogen atom 1

is bonded to two carbon atoms (and 1 hydrogen atom) 1

instead of to one carbon atom (and 2 hydrogen atoms) 1

as is characteristic of amino acids.

C. The secondary structure would be disrupted 1

because there will be no hydrogen atom present in the peptide bond, 1

and consequently no hydrogen bonding with other peptide bonds at other points in the polypeptide. 1

Possible: 7

Maximum: 7

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Biologically Important Molecules
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KfER.02R
GUIDELINE OBJECTIVE CODE: 11Kf
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: glycogen osmosis

Guideline Objective

The student will be expected to describe, using representative examples and structural formulas, the general structural features, the key subgroups, functional related linkages, and the main functions in living organisms, of carbohydrates, lipids, proteins, and nucleic acids.

Item Focus

Same as above.

Item

A. Describe the mechanism used by an animal cell to synthesize glycogen.

B. Explain clearly why it is advantageous to the cell to store material in the form of glycogen.

Response/Marking Scheme

A. Synthesis (any 4 points) 4

Glucose reacts with UTP, forming UDP-glucose, thus energizing the molecule, enabling the formation of glycosidic bonds (glu-glu), otherwise prevented by 2nd Law of Thermodynamics; The process needs a primer of glycogen, and continues, forming a macromolecule.

B. Advantages (any 4 points) 4

Osmotic pressure is a colligative property, depending on the number of molecules, not the mass; Glycogen has little influence on the cell's osmotic pressure, compared to glucose of the same energy value. The macromolecule thus stores considerable energy with little osmotic shock.

Possible: 8

Maximum: 8

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Biologically Important Molecules
CURRICULAR EMPHASIS: Practical Applications

INSTRUMENT CODE: B011KfER.03R
GUIDELINE OBJECTIVE CODE: 11Kf
INSTRUMENT TYPE: ER
KLOPFER: A1, A3, A7, A10, B1, B2, B3, B4, C2, D3, D6, F1, F2
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: amino acids chromatography

Guideline Objective

The student will be expected to describe, using representative examples and structural formulas, the general structural features, the key subgroups, functional related linkages, and the main functions in living organisms, of carbohydrates, lipids, proteins, and nucleic acids.

Item Focus

The student should be able to solve a medical problem involving the structure and functioning of amino acids.

Item

Refer to Figure 1K.30a and Figure 1K.30b.

CHROMATOGRAMS FOR THE DETECTION OF SUBSTANCES IN URINE

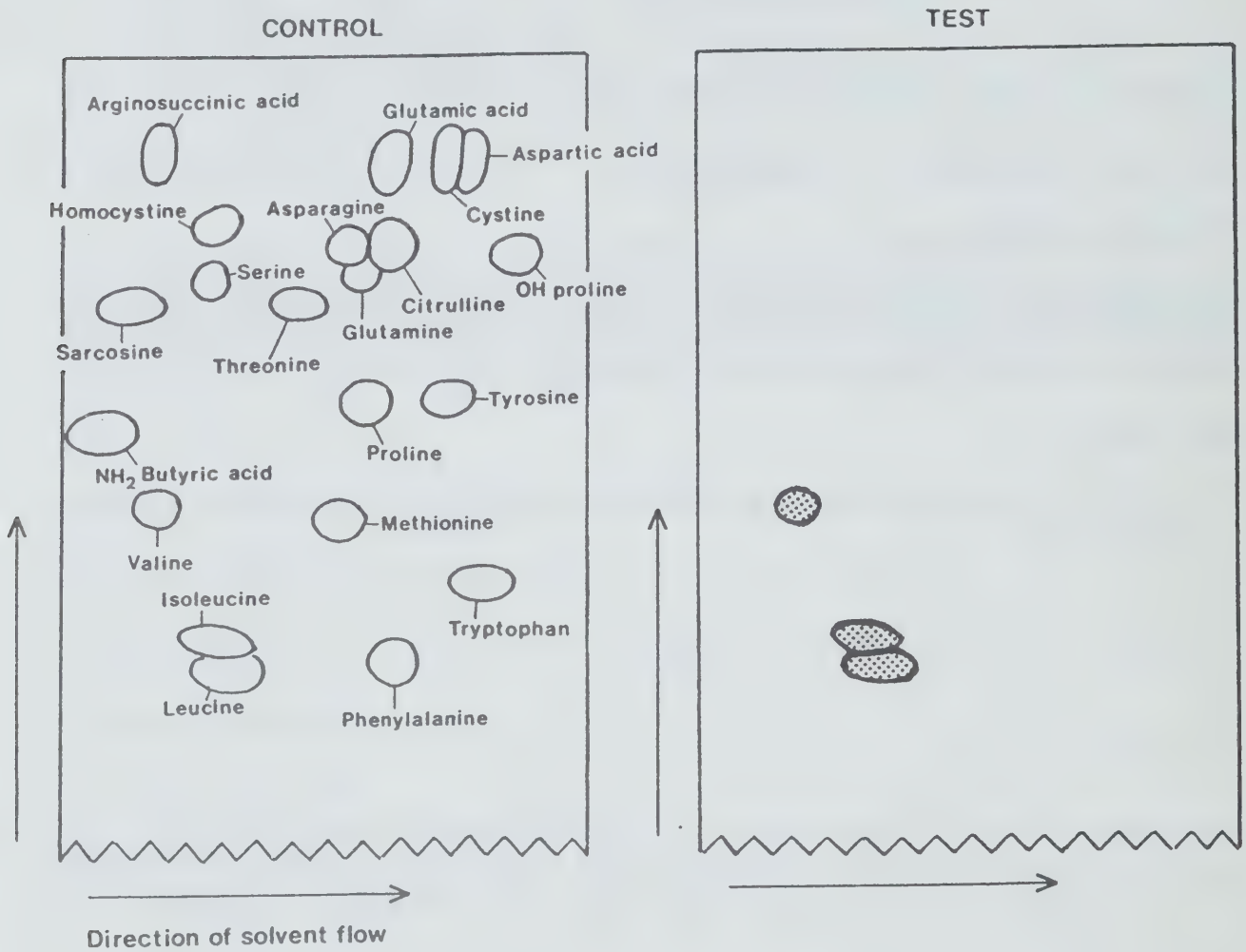


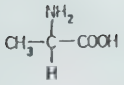
Figure 1K.30a shows that chromatography can be used to detect the presence, in urine, of many substances not normally found in human urine. The chromatogram labelled 'control' shows the locations of known amino acids when pure substances are separated by solvents run in two dimensions. A disease with a Canadian "flavour" (maple syrup urine disease) causes the chromatogram labelled 'test' to develop. This disease is hereditary, being inherited as an autosomal recessive trait.

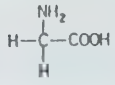
A. Name the substance(s) that accumulate(s) in the urine during maple syrup disease and explain how you were able to decide.

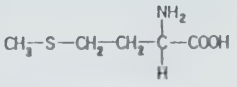
B. Examine the structural formulae of the substances in the table entitled "Some Substances That Could Be in Urine" (Figure 1K.30b) and suggest what structural feature was likely

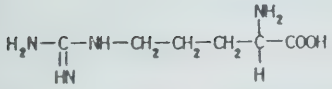
responsible for the accumulation of one or more of these substances in urine. Explain your reasoning.

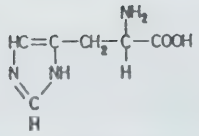
SOME SUBSTANCES THAT COULD BE IN URINE

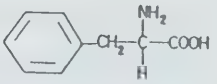

Alanine

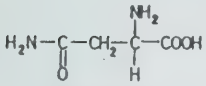

Glycine

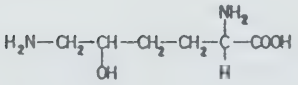

Methionine

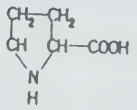

Arginine

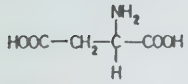

Histidine

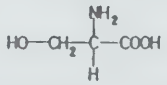

Phenylalanine

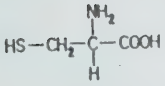

Asparagine

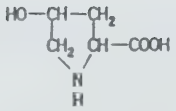

Hydroxylysine

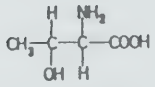

Proline

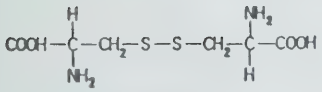

Aspartic acid

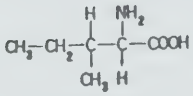

Serine

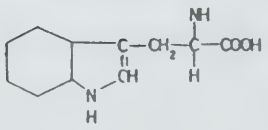

Cysteine

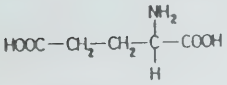

4 - Hydroxyproline

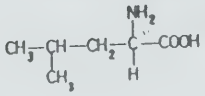

Threonine

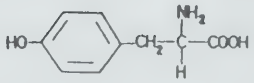

Cystine

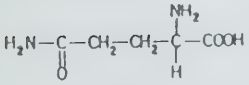

Isoleucine

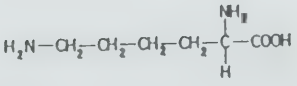

Tryptophan

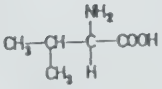

Glutamic acid


Leucine


Tyrosine


Glutamine


Lysine


Valine

Response/Marking Scheme

A. Valine, leucine, and isoleucine 3
are at elevated levels in the urine. This can be seen because the spots on the test chromatogram occupy positions that correspond to these three substances on the standard (control) chromatogram. 1

B. A branched hydrocarbon chain was responsible since 1
all three accumulated substances have it, and as 1
far as can be checked, no other accumulated substance that can be detected by the chromatographic technique has it. 1
Other features shared by the three (alpha-carboxyl alpha-amino) are also possessed by other chemicals that would have been detectable, had they been present in the urine, by the chromatographic technique. 1

Possible: 8

Maximum: 5

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Biologically Important Molecules
CURRICULAR EMPHASIS: Practical Applications

INSTRUMENT CODE: B011KfER.04R
GUIDELINE OBJECTIVE CODE: 11Kf
INSTRUMENT TYPE: ER
KLOPFER: A1, A3, A7, A10, B1, B2, B3, B4, C2, D3, D6, F1, F2
DIFFICULTY LEVEL: H
TIME ALLOCATION:

KEYWORDS: amino acid enzyme

Guideline Objective

The student will be expected to describe, using representative examples and structural formulas, the general structural features, the key subgroups, functional related linkages, and the main functions in living organisms, of carbohydrates, lipids, proteins, and nucleic acids.

Item Focus

The student should be able to solve a medical problem involving the structure and functioning of amino acids.

Item

In "maple syrup urine disease", three amino acids with branched chains occur in the urine of afflicted persons in elevated amounts. No straight-chain amino acids are affected. Such a disease might result from the deficiency of a single enzyme in some of the cells of individuals with the disease.

A. Explain, on the basis of the change of a single enzyme, how the three branched-chain amino acids might end up in the urine, while no straight-chain amino acids do.

There are two possible organs associated with the disease described above, the liver and the kidney.

B. Explain the differences in the function of enzymes in the liver and the kidney and their relationships to the accumulation of specific amino acids in the urine.

Response/Marking Scheme

A. The structural similarity in the branched-chain amino acids suggests that all are associated with a single enzyme, 1

that had evolved to fit branched-chain amino acids. 1

A change in this enzyme, involving the deletion or 1

insertion of a single amino acid might have distorted 1

its shape so that it no longer fits the compounds that it formerly catalyzed. 1

The fact that straight-chain amino acids are not affected shows that they are affected by a different enzyme. 1

B. If the deficiency were in the liver, the process might involve an enzyme that breaks up branched-chain amino acids, 1

removing the amino group from the carbon skeleton. 1

This normally produces urea, and makes the carbon 1

skeleton available for other syntheses, or for the release of energy. 1

In the absence of a functioning enzyme, the branched- chain amino acids are not deaminized, but excreted. 1

If the deficiency were in the kidney, the enzyme might be a permease responsible for the reabsorption 2

of the branched-chain amino acids.
This enzyme would be located in the cell membranes of 1

the epithelial cells lining the nephron tubules. 1

Normally, the enzyme would combine with branched- chain amino acids, and actively transport them from 1

the filtrate back into the tubule cells, or into the 1

blood.

Possible: 17

Maximum: 12

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Biologically Important Molecules
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KfMA.01
GUIDELINE OBJECTIVE CODE: 11Kf
INSTRUMENT TYPE: MA
KLOPFER: A.1, A.2, A.3, A.5
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: carbohydrate lipid nucleic acid protein

Guideline Objective

The student will be expected to describe, using representative examples and structural formulas, the general structural features, the key subgroups, functional related linkages, and the main functions in living organisms, of carbohydrates, lipids, proteins, and nucleic acids.

Item Focus

The student should be able to identify the functions of the main groups of biologically important molecules.

Item

From the right column, select the function or functions that are normally performed in biological systems by each of the classes of compounds listed in the left column. Enter the number(s) of the appropriate functions in the blank to the left of the names of the compounds.

A. _____	carbohydrates	1.	biological catalyst
		2.	energy storage (water insoluble)
		3.	energy storage (water soluble)
B. _____	lipids	4.	activates or represses gene
		5.	acts as a hormone
		6.	increases activation energy
C. _____	nucleic acids	7.	information storage
		8.	information transfer
		9.	absorbs light
D. _____	proteins	10.	acts as a biological solvent
		11.	transports water-insoluble substances

Response/Marking Scheme

1 mark for each correct match: A: 2, 3, 11; B: 2, 5, 10, 11; C: 7, 8; D: 1,3, 4, 5, 11

Possible: 14

Maximum: 10

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Biologically Important Molecules
CURRICULAR EMPHASIS: Communication

INSTRUMENT CODE: B011KfSA.01
GUIDELINE OBJECTIVE CODE: 11Kf
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.10
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: fats fatty acid glycerol

Guideline Objective

The student will be expected to describe, using representative examples and structural formulas, the general structural features, the key subgroups, functional related linkages, and the main functions in living organisms, of carbohydrates, lipids, proteins, and nucleic acids.

Item Focus

The student should be able to identify the reactants in a biological synthesis, given the molecular formula and a description of the reaction.

Item

A molecule of fat with the molecular formula $C_{45}H_{86}O_6$ was synthesized from a glycerol molecule ($C_3H_8O_3$) and three identical molecules of a fatty acid. What is the molecular formula of the fatty acid?

Response/Marking Scheme

Correct response:

$C_{14}H_{28}O_2$ or $CH_3(CH_2)12COOH$

Maximum: 3

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Fats
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KfSA.02
GUIDELINE OBJECTIVE CODE: 11Kf
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.10
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: ester linkage lipid

Guideline Objective

The student will be expected to describe, using representative examples and structural formulas, the general structural features, the key subgroups, functional related linkages, and the main functions in living organisms, of carbohydrates, lipids, proteins, and nucleic acids.

Item Focus

The student should be able to draw the molecular formula of a fat; identify the products of a condensation reaction, and identify the linkage formed.

Item

The molecular formula of oleic acid is $CH_3C_{16}H_{28}COOH$. The molecular formula of glycerol is $C_3H_8O_3$. A fat is formed when three molecules of oleic acid condense with one molecule of glycerol.

A. Draw the structural formula of the fat that is formed. (You may use R to represent the $CH_3C_{16}H_{28}$ part of the molecule.)

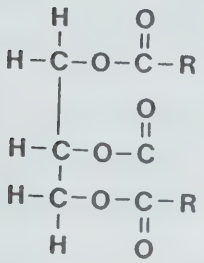
B. Name the second product formed in the dehydration synthesis (condensation).

C. Name the type of linkages formed between the reactants.

D. State three functions of fats in an organism.

Response/Marking Scheme

A. 3



B. Water 1

C. Ester linkages 1

D. Any 3 of the following: Fats store reserve energy. 1

Fats provide substrates that can enter metabolic pathways. 1

Fats form a major component of cell membranes. 1

Fats in the skin offer thermal insulation. 1

Fats serve as solvents for substances such as vitamins A and D 1

Possible: 10

Maximum: 8

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Chemical Reactions
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KgMC.01
GUIDELINE OBJECTIVE CODE: 11Kg
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: dehydration synthesis condensation

Guideline Objective

The student will be expected to compare condensation (dehydration synthesis) and hydrolysis reactions and describe their role in the synthesis and degradation of polymers.

Item Focus

The student should be able to identify a dehydration synthesis (condensation) reaction.

Item

Which of the following statements is an illustration of a condensation (dehydration synthesis) reaction?

- [ ] A. Acid + Base $\longrightarrow$ Salt + Water
- [ ] B. Oxidized substance + Reducing agent $\longrightarrow$ Reduced substance + Oxidized product
- [ ] C. 2 Reducing sugars $\longrightarrow$ Maltose + Water
- [ ] D. Starch + Water $\longrightarrow$ 2 Reducing sugars
- [ ] E. Dipeptide + Water $\longrightarrow$ 2 Amino acids

Response/Marking Scheme

Correct response: C

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Chemical Reactions
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KgMC.02
GUIDELINE OBJECTIVE CODE: 11Kg
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: hydrolysis lipid

Guideline Objective

The student will be expected to compare condensation (dehydration synthesis) and hydrolysis reactions and describe their role in the synthesis and degradation of polymers.

Item Focus

The student should be able to identify a reaction involving the hydrolysis of a fat.

Item

What type of chemical reaction is illustrated by the following equation?

Tristearin + Water $\longrightarrow$ Stearic acid + Glycerol

- [ ] A. Condensation (dehydration synthesis)
- [ ] B. Hydrolysis
- [ ] C. Oxidation
- [ ] D. Reduction
- [ ] E. Neutralization

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Chemical Reactions
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KgMC.03
GUIDELINE OBJECTIVE CODE: 11Kg
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: condensation dehydration synthesis

Guideline Objective

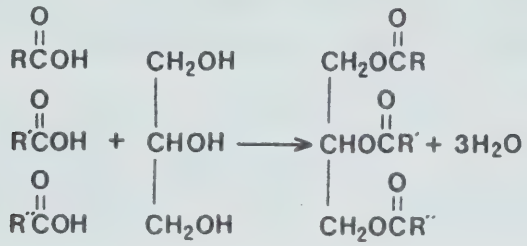
The student will be expected to compare condensation (dehydration synthesis) and hydrolysis reactions and describe their role in the synthesis and degradation of polymers.

Item Focus

The student should be able to identify the kinds of reactions involved in the formation of fats.

Item

Refer to Figure 1K.31 at this point.



Which of the following terms apply to the equation represented in Figure 1K.31 ?

I condensation (dehydration synthesis)
II esterification
III hydrolysis
IV emulsification
V neutralization

Choose your response from

☐ A. I, II, III

☐ B. I, III, IV

☐ C. II, IV, V

☐ D. II, III, V

☐ E. I, II, V

Response/Marking Scheme

Correct response: E

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Chemical Reactions
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KgMC.04
GUIDELINE OBJECTIVE CODE: 11Kg
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: dehydration synthesis condensation

Guideline Objective

The student will be expected to compare condensation (dehydration synthesis) and hydrolysis reactions and describe their role in the synthesis and degradation of polymers.

Item Focus

The student should be able to identify a major type of biochemical reaction from its description.

Item

The name for the type of biochemical reaction in which two organic molecules are joined and a water molecule is removed is

- [ ] A. reduction.
- [ ] B. oxidation.
- [ ] C. hydrolysis.
- [ ] D. hydrogenation.
- [ ] E. dehydration synthesis (condensation).

Response/Marking Scheme

Correct response: E

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Chemical Reactions
CURRICULAR EMPHASIS: Solid Foundations
KEYWORDS: hydrolysis

INSTRUMENT CODE: B011KgMC.05
GUIDELINE OBJECTIVE CODE: 11Kg
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

Guideline Objective

The student will be expected to compare condensation (dehydration synthesis) and hydrolysis reactions and describe their role in the synthesis and degradation of polymers.

Item Focus

The student should be able to identify types of chemical reactions.

Item

A chemical reaction that is considered to be the opposite of a dehydration synthesis (condensation) is called

- [ ] A. oxidation.
- [ ] B. neutralization.
- [ ] C. isomerization.
- [ ] D. hydrolysis.
- [ ] E. reduction.

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Chemical Reactions
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KgMC.06
GUIDELINE OBJECTIVE CODE: 11Kg
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: hydrolysis ester

Guideline Objective

The student will be expected to compare condensation (dehydration synthesis) and hydrolysis reactions and describe their role in the synthesis and degradation of polymers.

Item Focus

The student should be able to identify the products of a hydrolysis reaction.

Item

Molecules resulting from the hydrolysis of an ester are

- [ ] A. an acid and an alcohol.
- [ ] B. two sugars.
- [ ] C. an acid and an amine.
- [ ] D. two acids.
- [ ] E. a sugar and an acid.

Response/Marking Scheme

Correct response: A

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Chemical Reactions
CURRICULAR EMPHASIS: Solid Foundations
KEYWORDS: hydrolysis

INSTRUMENT CODE: B011KgMC.07
GUIDELINE OBJECTIVE CODE: 11Kg
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

Guideline Objective

The student will be expected to compare condensation (dehydration synthesis) and hydrolysis reactions and describe their role in the synthesis and degradation of polymers.

Item Focus

The student should be able to identify the products of a hydrolysis reaction.

Item

Molecules resulting from the hydrolysis of a dipeptide are

☐ A. an amino acid and an alcohol.

☐ B. two sugars.

☐ C. an acid and an amine.

☐ D. two amino acids.

☐ E. a sugar and an amino acid.

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Chemical Reaction
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KgMC.08
GUIDELINE OBJECTIVE CODE: 11Kg
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: hydrolysis starch

Guideline Objective

The student will be expected to compare condensation (dehydration synthesis) and hydrolysis reactions and describe their role in the synthesis and degradation of polymers.

Item Focus

The student should be able to identify the end-product of the hydrolysis of starch.

Item

Which of the following is the product of the hydrolysis of starch during digestion?

- [ ] A. sucrose
- [ ] B. maltose
- [ ] C. mannose
- [ ] D. lactose
- [ ] E. cellulose

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Chemical Reactions
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KgMC.09
GUIDELINE OBJECTIVE CODE: 11Kg
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: condensation dehydration synthesis

Guideline Objective

The student will be expected to compare condensation (dehydration synthesis) and hydrolysis reactions and describe their role in the synthesis and degradation of polymers.

Item Focus

The student should be able to identify the essential event in a dehydration synthesis (condensation) reaction.

Item

The synthesis of carbohydrates, fats, and proteins from smaller units involves the

- [ ] A. removal of nitrogen.
- [ ] B. temporary bonding to DNA.
- [ ] C. removal of water.
- [ ] D. addition of water.
- [ ] E. production of ATP.

Response/Marking Scheme

Correct response: C

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Chemical Reactions
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KgMC.10
GUIDELINE OBJECTIVE CODE: 11Kg
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: condensation dipeptide

Guideline Objective

The student will be expected to compare condensation (dehydration synthesis) and hydrolysis reactions and describe their role in the synthesis and degradation of polymers.

Item Focus

The student should be able to identify the product of a condensation reaction between two amino acids.

Item

Refer to Figure 1K.32.

STRUCTURAL FORMULAE OF TWO MOLECULES

When the molecules shown in Figure 1K.32 undergo a dehydration synthesis (condensation) reaction, the products formed are water and

- [ ] A. a dipeptide.
- [ ] B. an aldehyde.
- [ ] C. a ketone.
- [ ] D. an ester.
- [ ] E. an ether.

Response/Marking Scheme

Correct response: A

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Chemical Reactions
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KgMC.11
GUIDELINE OBJECTIVE CODE: 11Kg
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: dehydration synthesis protein condensation

Guideline Objective

The student will be expected to compare condensation (dehydration synthesis) and hydrolysis reactions and describe their role in the synthesis and degradation of polymers.

Item Focus

The student should be able to identify the essential process of a dehydration synthesis (condensation) reaction in the synthesis of a protein.

Item

Dehydration synthesis reactions (condensation) which result in the production of a protein in a cell

- [ ] A. determine the sequence of amino acids in the polypeptide chain.
- [ ] B. combine amino acid molecules, with the removal of water.
- [ ] C. result in the formation of the alpha helix.
- [ ] D. are essential to the folding of the protein chain.
- [ ] E. combine amino acid molecules, with the addition of water.

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Chemical Reactions
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KgMC.12
GUIDELINE OBJECTIVE CODE: 11Kg
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: dehydration synthesis condensation

Guideline Objective

The student will be expected to compare condensation (dehydration synthesis) and hydrolysis reactions and describe their role in the synthesis and degradation of polymers.

Item Focus

The student should be able to identify the reactions involved in producing common organic compounds.

Item

Dehydration synthesis (condensation) reactions are involved in the formation of all of the following substances EXCEPT

- [ ] A. peptides.
- [ ] B. carbon dioxide.
- [ ] C. glucosides.
- [ ] D. esters.
- [ ] E. ethers.

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Chemical Reactions
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KgMC.13
GUIDELINE OBJECTIVE CODE: 11Kg
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: lipid hydrolysis

Guideline Objective

The student will be expected to compare condensation (dehydration synthesis) and hydrolysis reactions and describe their role in the synthesis and degradation of polymers.

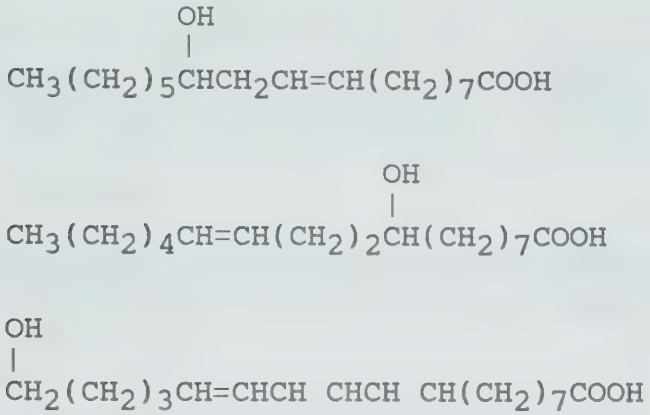
Item Focus

The student should be able to identify a major type of biochemical reaction from its description.

Item

Refer to Figure 1K.33.

STRUCTURAL FORMULAE



The formulae in Figure 1K.33 represent some of the products that result from the hydrolysis of

- A. fats.
- B. polypeptides.
- C. polynucleotides.
- D. polysaccharides.
- E. polyribosomes.

Response/Marking Scheme

Correct response: A

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Chemical Reactions
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KgMC.15
GUIDELINE OBJECTIVE CODE: 11Kg
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: biosynthesis fats

Guideline Objective

The student will be expected to compare condensation (dehydration synthesis) and hydrolysis reactions and describe their role in the synthesis and degradation of polymers.

Item Focus

The student should be able to able to identify the products of the biosynthesis of fats.

Item

In the overall equation for the biosynthesis of fats from fatty acids and glycerol, one of the products is

- [ ] A. pyrophosphate.
- [ ] B. water.
- [ ] C. phosphoglycerol.
- [ ] D. ATP.
- [ ] E. coenzyme A.

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Chemical Reactions
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KgMC.16
GUIDELINE OBJECTIVE CODE: 11Kg
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.7
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: fats fatty acid neutralization

Guideline Objective

The student will be expected to compare condensation (dehydration synthesis) and hydrolysis reactions and describe their role in the synthesis and degradation of polymers.

Item Focus

The student should be able to identify the products of the hydrolysis of a fat.

Item

If the fatty acids contained within one fat molecule were neutralized with sodium hydroxide, the number of hydroxyl ions consumed would be

- [ ] A. 0
- [ ] B. 1
- [ ] C. 2
- [ ] D. 3
- [ ] E. 4

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Chemical Reactions
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KgMC.17
GUIDELINE OBJECTIVE CODE: 11Kg
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL:
TIME ALLOCATION:

KEYWORDS: hydrolysis ester

Guideline Objective

The student will be expected to compare condensation (dehydration synthesis) and hydrolysis reactions and describe their role in the synthesis and degradation of polymers.

Item Focus

The student should be able to identify the products of a hydrolysis reaction.

Item

Molecules resulting from the hydrolysis of an ester are

- [ ] A. an acid and a sugar.
- [ ] B. two sugars.
- [ ] C. an acid and an amine.
- [ ] D. two acids.
- [ ] E. an acid and an alcohol.

Response/Marking Scheme

Correct response: E

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Chemical Reactions
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KgSA.01
GUIDELINE OBJECTIVE CODE: 11Kg
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: lipid fats hydrolysis

Guideline Objective

The student will be expected to compare condensation (dehydration synthesis) and hydrolysis reactions and describe their role in the synthesis and degradation of polymers.

Item Focus

The student should be able to draw the structural formulae involved in the digestion of a fat, and write a word equation to represent the reaction.

Item

Draw the structural formulae involved when digestion in an organism separates a molecule of fat into its constituents. Write a word equation for the reaction.

Response/Marking Scheme

Fat molecule+water$\longrightarrow$Fatty acids+Glycerol 2

$$\begin{array}{l} R_1C-O-HCH_2 \\ \quad\quad\quad | \\ R_2C-O-HCH \\ \quad\quad\quad | \\ R_3C-O-HCH_2 \end{array} + 3H_2O \longrightarrow \begin{array}{l} R_1COOH \\ R_2COOH \\ R_3COOH \end{array} + \begin{array}{l} CH_2OH \\ | \\ CHOH \\ | \\ CH_2OH \end{array}$$ 5

Possible: 7

Maximum: 7

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Functional Groups and Linkages
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KhMC.01
GUIDELINE OBJECTIVE CODE: 11Kh
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.6, A.10
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: peptide linkage amino acid protein

Guideline Objective

The student will be expected to describe in general terms the components of protein structure and the importance of this structure in the role of such biologically active proteins as enzymes and hormones.

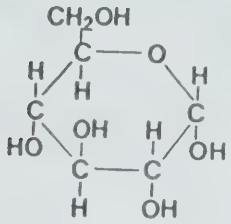
Item Focus

The student should be able to identify amino acids as compounds that will form peptide linkages.

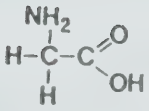
Item

Refer to Figure 1K.25.

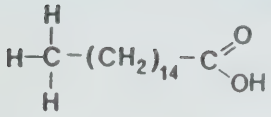
A.



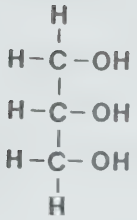
B.



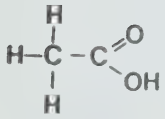
C.



D.



E.



Which molecule shown in Figure 1K.25 is able to form peptide linkages with other similar molecules?

- [ ] A.
- [ ] B.
- [ ] C.
- [ ] D.
- [ ] E.

Response/Marking Scheme

Correct response: B

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B011KhMC.02
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 11Kh
UNIT NUMBER: 01	INSTRUMENT TYPE: MC
UNIT NAME: CHEMICAL BASIS OF LIFE	KLOPFER: A.1, A.2, A.3
	DIFFICULTY LEVEL: L
TOPIC: Peptide Linkage	TIME ALLOCATION:
CURRICULAR EMPHASIS: Solid Foundations	
KEYWORDS: peptide linkage amino acid	

Guideline Objective

The student will be expected to describe in general terms the components of protein structure and the importance of this structure in the role of such biologically active proteins as enzymes and hormones.

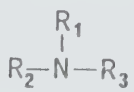
Item Focus

The student should be able to identify a peptide linkage in a structural formula.

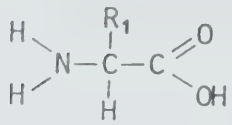
Item

Refer to Figure 1K.35.

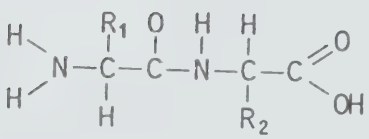
A.



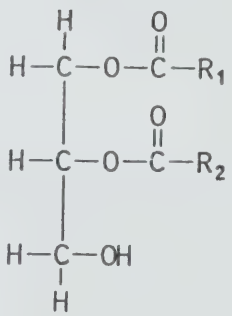
B.



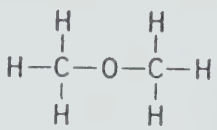
C.



D.



E.



Which formula in Figure 1K.35 represents a peptide linkage?

Response/Marking Scheme

Correct response: C

Teacher Notes

Response/Marking Scheme

In the lock and key model of enzyme action, the lock is analogous to the substrate,
starch, and the key is analogous to the enzyme, salivary amylase (ptyalin). 1

The key will only open one lock. 1

To open a lock, the notches and grooves of a key must match the tumblers of the lock. 1

Similarly, to catalyze a chemical reaction, the structure of the active site of the protein molecule which is the enzyme
must match precisely the molecular structure of the substrate. 2

The active site of the enzyme precisely matched the 1-4 ether linkages bonding adjacent glucose units of the starch together, thus catalyzing the breakdown. 2

The 1-4 ether linkages bonding the glucose units in cellulose
are different from those in starch. 1

In starch, both covalent bonds from the bridge oxygen to the 1st and 4th carbons
of the glucose rings are directed upward to the plane of the rings; 1

while in cellulose, the bond from the bridge oxygen to the #1 carbon of the ring
is directed downward to the plane of that ring; the other bond to the #4 carbon is
the same as in the starch molecule. 1

This small difference is sufficient to prevent the active site of the enzyme
from bonding with cellulose, 1

preventing the catalysis, and illustrating a very high degree of specificity. 1

After the key opens a lock, it is unaltered, and can open any other identical locks;
the lock is altered. 1

Although both enzyme and substrate change shape slightly when they combine,

the enzyme reverts to its original shape when the reaction is complete,
and is available for further catalyses; the substrate is altered. 2

Possible: 15

Maximum: 12

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Protein Structure/Function
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B011KhER.05
GUIDELINE OBJECTIVE CODE: 11Kh
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, A.7, A.9, A.10, C.2, D.2, D.3, E.4, E.5, F.1
DIFFICULTY LEVEL: H
TIME ALLOCATION:

KEYWORDS: enzyme inhibition graphical analysis

Guideline Objective

The student will be expected to describe, in general terms, the components of protein structure and the importance of this structure in the role of such biologically active proteins as enzymes and hormones.

Item Focus

The student should be able to extend knowledge of the mechanism of enzyme functioning to a new situation.

Item

There are two ways that enzymes may be inhibited. Competitive inhibition occurs when another chemical interacts loosely (in equilibrium) with the active site of the enzyme, in the same way as the normal substrate does, but does not undergo any reaction. Non-competitive inhibition is caused by a chemical interacting strongly with another part of the enzyme (not the active site), in such a way as to change its shape so that the enzyme is no longer able to function normally.

Refer to Figure 1K.38.

ENZYME ACTION, WITH AND WITHOUT INHIBITION

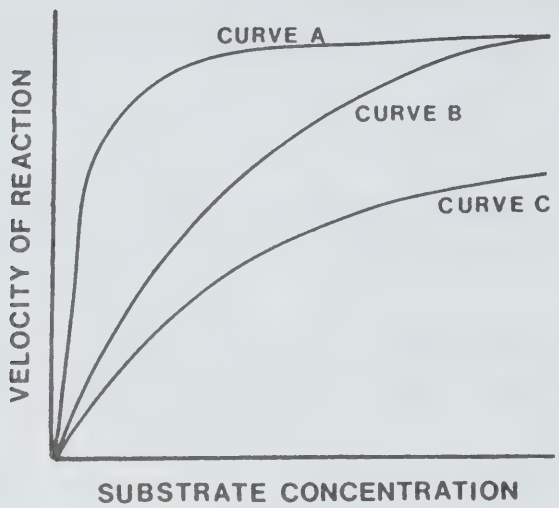


Figure 1K.38 presents three curves, labelled "A", "B", and "C". Each curve shows the relationship between the velocity of an enzyme-catalyzed reaction and substrate concentration. One of the curves represents the relationship for a normal, uninhibited enzyme. The other two curves show the relationship for enzymes inhibited by one of the mechanisms discussed above.

Identify clearly, using the letters assigned to the curves, which curve belongs to each situation (competitive inhibition, non-competitive inhibition, uninhibited). Explain, briefly the basis of your decision.

(Assume that the concentration of the enzyme is identical in each case, and that, when an inhibitor is present, its concentration is always the same.)

Response/Marking Scheme

Curve A is uninhibited,	1
because the reaction goes fastest at all substrate concentrations.	1
Curve B is competitively inhibited,	1
because the rate approaches the maximum as substrate concentrations reach high enough proportions to outnumber greatly the inhibitor molecules.	1
Curve C is non-competitively inhibited,	1
because the rate does not approach the maximum due to the effective removal or destruction of some enzyme molecules by the inhibitor.	1
Possible:	6
Maximum:	5

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B011KhER.06
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 11Kh
UNIT NUMBER: 01	INSTRUMENT TYPE: ER
UNIT NAME: CHEMICAL BASIS OF LIFE	KLOPFER: A.1, A.2, A.3, A.8, A.9, D.2, D.3
TOPIC: Protein Functioning	DIFFICULTY LEVEL: H
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:

KEYWORDS: enzyme denaturation graphical analysis

Guideline Objective

The student will be expected to describe, in general terms, the components of protein structure and the importance of this structure in the role of such biologically active proteins as enzymes and hormones.

Item Focus

The student will explain the effect of heat and pH changes on the shape and activity of enzymes (denaturation).

Item

Refer to Figure 1K.39.

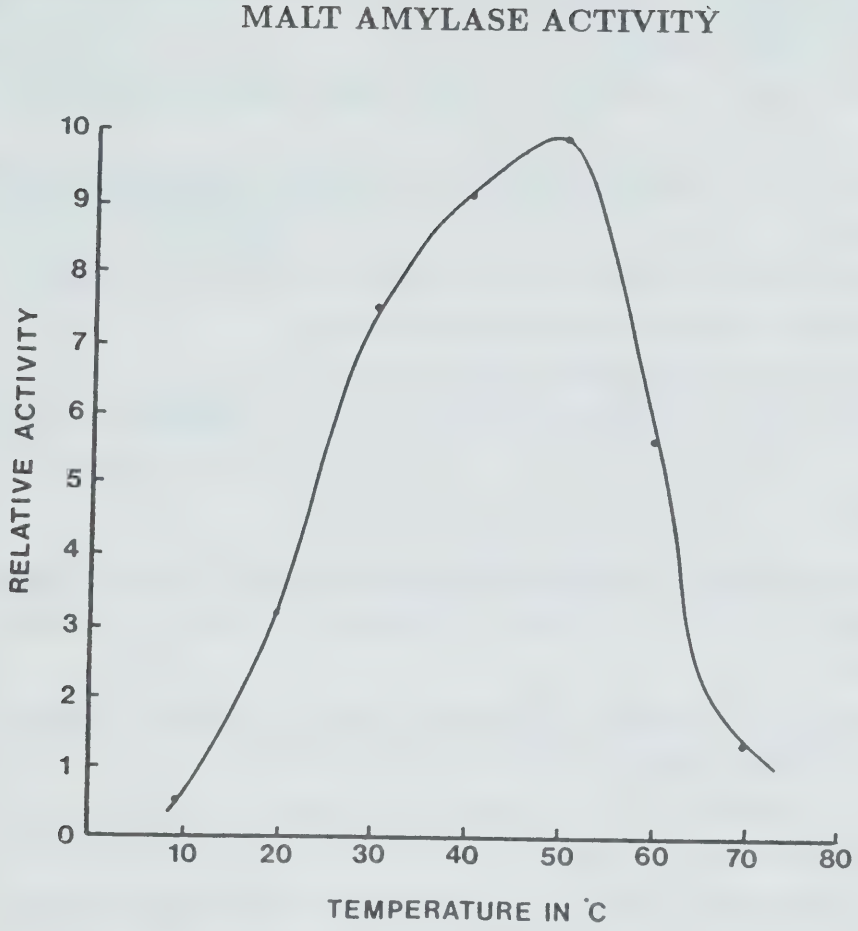


Figure 1K.39 is a graph of how the activity of an enzyme, malt amylase, varies with temperature. Account for the relative activity of the enzyme at different temperatures in terms of

A. enzyme structure

B. temperature and kinetic energy

C. bonding

Response/Marking Scheme

A. The maximum (optimum) activity at approximately 50°C indicates the tertiary and quaternary structure 2
of the enzyme brings the amino acids together appropriately for catalysis to occur. 1

B. Above 50°C, the rapid decline of activity is a consequence of heat denaturation of the enzyme. 1
Heat raises the kinetic energy of each amino acid side chain in the molecule. 1
This weakens their interaction with other side chains, 1
disrupting the tertiary and quaternary structure, 1
making the arrangements of residues at the active site less suitable for catalysis. 1
The further the temperature is above the optimum, the greater will be the cumulative effect of such weakenings on the structure. 1

C. At temperatures below the optimum, there are two effects that can reduce enzyme activity; neither is as disastrous as heating, as shown by the more gradual curve. 1
First, as temperature decreases, the kinetic energy of substrate molecules (starch and water) is reduced. 1
This leads to a reduction of the proportion of substrate molecules having sufficient activation energy to react. 1
Second, is the disruption of enzyme shape, due to the weakening of hydrophobic bonds at low temperature. 1

Possible: 13

Maximum: 10

Quality: 2

Total: 12

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Protein Functioning
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KhER.08
GUIDELINE OBJECTIVE CODE: 11Kh
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.3
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: enzyme synthesis

Guideline Objective

The student will be expected to describe in general terms the components of protein structure and the importance of this structure in the role of such biologically active proteins as enzymes and hormones.

Item Focus

The student should be able to explain the role of an enzyme in synthesis.

Item

Explain how an enzyme is able to catalyze the synthesis of a large molecule from 2 smaller molecules.

Response/Marking Scheme

An enzyme is a protein molecule	1
with characteristic 3-dimensional shape	1
that can match up to the specific shape of its substrates	1
and bind to them by hydrogen bonds, at active sites,	1
forming an enzyme-substrate complex.	1
By distorting the shapes of the substrates, the enzyme	1
lowers their activation energy, allowing them	1
to bond together to make the large molecule,	1
which is then released from the enzyme.	

Possible: 9

Maximum: 5

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Protein Functioning
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B011KhLA.01
GUIDELINE OBJECTIVE CODE: 11Kh
INSTRUMENT TYPE: LA
KLOPFER: A.1, A.2, A.3, A.9, D.2, D.3, E.5, E.6
DIFFICULTY LEVEL: H
TIME ALLOCATION:

KEYWORDS: enzyme denaturation lock and key model

Guideline Objective

The student will be expected to describe, in general terms, the components of protein structure and the importance of this structure in the role of such biologically active proteins as enzymes and hormones.

Item Focus

The student should be able to apply the model of enzyme action to explain data on enzyme denaturation.

Item

The enzyme, subtilisin, digests proteins. Its ability to do so is lost irreversibly when it is treated with the oxidizing agent, hydrogen peroxide. This inactivation is ten times as fast when the subtilisin is in the presence of a digestive protein as when there is no substrate present. Explain this inactivation in terms of current models of enzyme structure and functioning.

Response/Marking Scheme

The hydrogen peroxide reacts chemically	1
with one or more of the amino acid side groups	1
of the enzyme.	
Either the reaction occurs with a side chain participating in the active site,	1
or one vital in maintaining the proper tertiary/quaternary structure	
to bring participants in the active site into propinquity.	1
Since inactivation is greatly accelerated by in the presence of substrate, the enzyme	
must change its shape when substrate is present.	1
thereby exposing a vulnerable side chain not exposed to	1
the peroxide in the enzyme's native state.	1
This evidence supports the "induced fit" model of enzyme activity	1
and casts doubt upon the "lock and key" model.	

Possible: 8

Maximum: 5

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Protein Functioning
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B011KhLA.02
GUIDELINE OBJECTIVE CODE: 11Kh
INSTRUMENT TYPE: LA
KLOPFER: A.1, A.2, A.3, A.6, A.7, A.8, C.1, C.2
DIFFICULTY LEVEL: H
TIME ALLOCATION:

KEYWORDS: starch cellulose enzyme

Guideline Objective

The student will be expected to describe, in general terms, the components of protein structure and the importance of this structure in the role of such biologically active proteins as enzymes and hormones.

Item Focus

The student should be able to use the lock and key model of enzyme specificity to account for the action of the enzyme salivary amylase (ptyalin) on starch but not on cellulose.

Item

A student investigated the action of saliva on a suspension of starch and on a suspension of cellulose by setting up the following test tubes:

1. 2 mL of starch suspension
2. 2 mL of cellulose suspension
3. 2 mL of saliva
4. 2 mL of starch suspension + 2mL of saliva
5. 2 mL of cellulose suspension + 2 mL of saliva

The pH of each test tube was 7.5. The test tubes were maintained in a water bath at 37°C for 10 min. A Benedict's test was then carried out on the contents of each test tube. The following observations were recorded:

1. blue (no change)
2. blue (no change)
3. blue (no change)
4. brick red
5. blue (no change)

A. Interpret the observations.

B. Why were test tubes 1, 2, and 3 set up? What did they show?

C. Explain the result in test tube 4.

D. Use the lock and key model to explain why the starch was changed, but not the cellulose. Refer to the molecular structure of starch and cellulose in your answer.

Response/Marking Scheme

A. Benedict's solution tests for the presence of a reducing sugar. Reducing sugar was formed in test tube 4, but was not present in the other tubes. 2

B. Test tubes 1, 2, and 3 were controls. 1
Their purpose was to establish whether reducing sugar was present in the starch, cellulose, or saliva, 1
and to establish whether other factors than saliva acting on the starch might have produced the sugar. 1
The controls showed that no reducing sugar was initially present, and that 1
none of the ingredients, acting alone, produced reducing sugar. 1

C. Saliva contains the enzyme salivary amylase (ptyalin) 1
which catalyzed the breakdown of starch to maltose, 1
the reducing sugar that gave the positive response to Benedict's test. 1

D. In the lock and key model of enzyme action, the lock is analogous to the substrate,
starch, and the key is analogous to the enzyme, salivary amylase (ptyalin). 1
The key will only open one lock. 1
To open a lock, the notches and grooves of a key must match the tumblers of the lock. 1
Similarly, to catalyze a chemical reaction, the structure of the active site of the protein molecule which is the enzyme
must match precisely the molecular structure of the substrate. 2
The active site of the enzyme precisely matched the 1-4 ether linkages bonding adjacent glucose units of the starch together, thus catalyzing the breakdown. 2
The 1-4 ether linkages bonding the glucose units in cellulose
are different to those in starch. 1
In starch, both covalent bonds from the bridge oxygen to the 1st and 4th carbons
of the glucose rings are directed upward to the plane of the rings; 1
while in cellulose, the bond from the bridge oxygen to the #1 carbon of the ring
is directed downward to the plane of that ring;
the other bond to the #4 carbon is the same as in the starch molecule. 1
This small difference is sufficient to prevent the active site of the enzyme from bonding with cellulose, 1
preventing the catalysis, and illustrating a very high degree of specificity. 1

After the key opens a lock, it is unaltered, and can open any other identical locks;
the lock is altered. 1

Although both enzyme and substrate change shape slightly when they combine,

the enzyme reverts to its original shape when the reaction is complete,
and is available for further catalyses; the substrate is altered. 2

Possible: 25

Maximum: 16

Quality: 2

Total: 18

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B011KhLA.03
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 11Kh
UNIT NUMBER: 01	INSTRUMENT TYPE: LA
UNIT NAME: CHEMICAL BASIS OF LIFE	KLOPFER: A.1, A.2, A.3, A.6, A.7, A.8, C.1, C.2
TOPIC: Protein Functioning	DIFFICULTY LEVEL: H
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:
KEYWORDS: starch cellulose enzyme	

Guideline Objective

The student will be expected to describe, in general terms, the components of protein structure and the importance of this structure in the role of such biologically active proteins as enzymes and hormones.

Item Focus

The student should be able to use the lock and key model of enzyme specificity to account for the action of the enzyme salivary amylase (ptyalin) on starch but not on cellulose.

Item

A student investigated the action of saliva on a suspension of starch and on a suspension of cellulose. Use the lock and key model to explain why the starch was changed, but not the cellulose. Refer to the molecular structure of starch and cellulose in your answer.

Response/Marking Scheme

In the lock and key model of enzyme action, the lock is analogous to the substrate, starch, and the key is analogous to the enzyme, salivary amylase (ptyalin).	1
The key will only open one lock.	1
To open a lock, the notches and grooves of a key must match the tumblers of the lock.	1
Similarly, to catalyze a chemical reaction, the structure of the active site of the protein molecule (the enzyme) must match precisely the molecular structure of the substrate.	2
The active site of the enzyme precisely matched the 1-4 ether linkages bonding adjacent glucose units of the starch together, thus catalyzing the breakdown.	2
The 1-4 ether linkages bonding the glucose units in cellulose are different to those in starch.	1
In starch, both covalent bonds from the bridge oxygen to the 1st and 4th carbons of the glucose rings are directed upward to the plane of the rings;	1
while in cellulose, the bond from the bridge oxygen to the #1 carbon of the ring is directed downward to the plane of that ring; the other bond to the #4 carbon is the same as in the starch molecule.	1
This small difference is sufficient to prevent the active site of the enzyme from bonding with cellulose,	1
preventing the catalysis, and illustrating a very high degree of specificity.	1
After the key opens a lock, it is unaltered, and can open any other identical locks; the lock is altered.	1
Although both enzyme and substrate change shape slightly when they combine, the enzyme reverts to its original shape when the reaction is complete, and is available for further catalyses; the substrate is altered.	2
Possible:	15
Maximum:	12

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Protein Functioning
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B011KhLA.04
GUIDELINE OBJECTIVE CODE: 11Kh
INSTRUMENT TYPE: LA
KLOPFER: A.1 to 4, A.7, A.8, D.1 to 4, D.6

DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: enzyme graphical analysis

Guideline Objective

The student will be expected to describe, in general terms, the components of protein structure and the importance of this structure in the role of such biologically active proteins as enzymes and hormones.

Item Focus

The student should be able to interpret data obtained from a laboratory experiment showing the effects of temperature on the activity of an enzyme.

Item

Introduction: A laboratory activity has been carried out to investigate the problem, How does temperature affect the activity of the enzyme, peroxidase (catalase)? The procedure used was to make an extract of fresh liver (the source of the peroxidase). Small discs of filter paper (1 cm in diameter) were soaked in the extract, and then dropped into test-tubes containing 10 mL of hydrogen peroxide. The enzyme peroxidase breaks down hydrogen peroxide into oxygen and water. A measure of the rate of enzyme action is the rate of production of oxygen. This in turn is indicated by the amount of time taken for the discs (which originally sink) to float to the surface (buoyed up by bubbles of oxygen). For the experiment, different test-tubes of hydrogen peroxide were maintained at different temperatures.

You will have 10 min to graph, analyze and interpret the data obtained from this experiment.

DATA TABLE

THE EFFECTS OF TEMPERATURE ON THE ACTIVITY OF PEROXIDASE

Temperature	Time taken for discs to float
°C	s
0	20.0
10	18.0
20	13.0
30	6.5
40	2.5
50	23.0

Response/Marking Scheme

GRAPH:	
suitable title	1
correct axes	1
suitable scales	2
points correctly plotted	1
curve correctly drawn	1
ANALYSIS: Fastest rise to surface means highest rate of enzyme activity.	2
INTERPRETATION: At low temperature (0°C), enzyme activity is slow	1
because molecules are not moving as quickly.	1
As temperature increases, the rate of action increases,	1
to a maximum (optimum) at 40°C.	1
Above the optimum, heat distorts the shape of	1
the enzyme, slowing the activity.	1
Possible:	14
Maximum:	10

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Biologically Important Molecules
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KhSA.01
GUIDELINE OBJECTIVE CODE: 11Kh
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: enzyme

Guideline Objective

The student will be expected to describe, in general terms, the components of protein structure and the importance of this structure in the role of such biologically active proteins as enzymes and hormones.

Item Focus

The student should be able to define the term enzyme, give an example of an enzyme, and describe the mechanism of action of an enzyme.

Item

A. Define the term enzyme, and give one example of an enzyme.

B. Briefly describe the mechanism of action of an enzyme.

Response/Marking Scheme

A. An enzyme is composed of protein	1
and serves as a catalyst in a biological system	1
E.g. salivary amylase (or other)	1
B. Enzymes combine reversibly with substrates	1
to form an enzyme-substrate complex.	1
The reaction depends on the 3-dimensional shape of the molecule.	1
Enzymes reduce the activation energy required for a reaction.	1
Reference to lock-and-key model.	1
Possible:	8
Maximum:	7

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Enzyme Activity
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B012b-MC.01
GUIDELINE OBJECTIVE CODE: 12b
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, D.3
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: variable rate graphical analysis

Guideline Objective

The student will design and perform experiements to investigate enzymatic activity and the effects of one or more of the following factors: temperature, concentration of substrate and/or enzyme, and pH.

Item Focus

The student should be able to interpret data obtained from an experiment in which factors affecting the rate of enzyme activity were examined.

Item

Refer to Figure 1S.1 to answer this question.

THE ACTION OF CATALASE ON HYDROGEN PEROXIDE

The graph shown in Figure 1S.1 was obtained by a student investigating the action of the enzyme catalase on the substrate hydrogen peroxide. The variable that the student was manipulating to produce the data for the three curves must have been

- [ ] A. the temperature of the reaction.
- [ ] B. the concentration of the enzyme.
- [ ] C. the concentration of the hydrogen peroxide.
- [ ] D. the pH of the system.
- [ ] E. the volume of the enzyme extract.

Response/Marking Scheme

Correct response: C

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Buffers
CURRICULAR EMPHASIS: Nature of Science
KEYWORDS: acid base pH lab

INSTRUMENT CODE: B012d-LE.01
GUIDELINE OBJECTIVE CODE: 12d
INSTRUMENT TYPE: LE
KLOPFER: A.1, A.2, A.3, B.1, B.2, C.2, D.3, D.6, G.2
DIFFICULTY LEVEL: M
TIME ALLOCATION:

Guideline Objective

Students are to prepare and test a buffer solution.

Item Focus

The students should be able to prepare a buffer solution, test its action with acid and base, and explain the observed results.

Item

In this laboratory exercise, you are to prepare a buffer solution, and to test its action on an acid and a base. After you observe the action of the buffer, you will be asked to explain your observations. You will have about 30 min to complete the task.

Procedure:

1. Arrange 5 clean test tubes in the test tube rack, and label them A, B, C, D, E.
2. Measure 15 mL of 0.1 mol/L acetic acid solution into the graduated cylinder. Use the balance to measure 0.10 g sodium acetate. Add the solid to the acetic acid and shake the mixture until it dissolves. This is the buffer solution.
3. Divide the buffer solution equally 5 mL into each of test tube B, C, and D.
4. Measure 5 mL of distilled water into each of test tubes A and E.
5. Add two drops of indicator solution to each of the five test tubes. Record your observations.
6. To each of test tubes A and B, add 5 mL of 0.1 mol/L hydrochloric acid. Record your observations.
7. To each of test tubes D and E, add 5 mL of 0.1 mol/L sodium hydroxide. Record your observations.
8. Explain the significance of each of the test tubes in establishing the action of a buffer. What do buffers do?

Response/Marking Scheme

Test tube	Observation		Significance	Mark
	Step 5	Step 6,7		
A	yellow	pink	shows the effect of acid on universal indicator	3
B	orange	orange	show the effect of acid and buffer: no change in pH	3
C	orange	orange	control: shows the colour of the indicator in buffer solution	3
D	orange	orange	shows the effect of base and buffer: no change in pH	3
E	yellow	purple	shows the effect of base on universal indicator	3

A buffer can neutralize either acid or base without letting the pH change. Buffers thus control pH within limits. 3

Possible: 18

Maximum: 15

Teacher Notes

1. The purpose of this laboratory exercise is to evaluate the students' skills in measuring mass and volume, and their ability to explain the action of a buffer.

2. The activity should take about 30 min.

3. Give the students a table for their observations to simplify the marking.

Materials: (per student)

10 mL	distilled water
15 mL 0.1 mol/L	acetic acid
0.1 mol/L	hydrochloric acid
0.1 mol/L	sodium hydroxide
0.1 g	sodium acetate
few drops	universal indicator sol'n
5	test tubes (100 mL size)
1	test tube rack
1	graduated cylinder
1	balance
1	stopper to fit cylinder

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Medical Applications
CURRICULAR EMPHASIS: Science, Technology and Society

INSTRUMENT CODE: B014a-ER.01
GUIDELINE OBJECTIVE CODE: 14a
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.3, I.5
DIFFICULTY LEVEL: H
TIME ALLOCATION:

KEYWORDS: biochemical processes medical science insulin.

Guideline Objective

Students will understand that knowledge of biochemical processes has led to significant advances in medical procedures and health care generally.

Item Focus

Students will understand that the use of scientific knowledge often raises difficult questions that merit societal consideration.

Item

Increased knowledge of biochemical processes has led to advances in medical procedures and health care. However, this increase in knowledge has contributed to a number of serious societal problems.

Describe one major societal problem which is a direct result of the advancement of biochemical knowledge. In your description, point out how the negative impact of this knowledge might have been lessened.

Response/Marking Scheme

Students can choose from a number of examples. In their answer, they should show how there is a direct link between the societal problem and the increased knowledge.

Appropriate example	1
Statement of societal problem	2
Link between problem and increased development	2
How the negative impact might have been reduced	2

Example: The discovery of a technique for isolating insulin for the treatment of diabetes mellitus. The discovery of a technique for isolating insulin lead to ways of supplying insulin to diabetics allowing for the symptoms of the disease to be treated. Unfortunately, severe side-effects of the disease (e.g. poor circulation, gangrene, sight impairment, etc.) continue to plague diabetics. In addition to the high toll placed on diabetics in terms of their personal health, significant amounts of money from the public purse must be spent each year to hospitalize and treat some of the more serious cases. One ramification of the discovery of an effective technique to isolate insulin was that comparatively little interest and research money went into studying possible cure or preventative measures concerning the disease. Until it became apparent that diabetics could suffer severe long- term effects even with the administration of insulin, little was done in the way of research. If provision had been made for the continued search for cures or preventative measures to treat diabetes, it is reasonable to assume that medical science might have advanced in that direction. Perhaps patent rights could be granted to companies with stringent provision for the diverting of profits into diabetes research.

Possible: 7

Maximum: 5

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Biologically Important Molecules
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B017a-SA.01
GUIDELINE OBJECTIVE CODE: 17a
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.3, I.3
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: Urey and Miller assumptions hypothesis

Guideline Objective

The students might discuss various scientific hypotheses relating to the origin of complex organic molecules.

Item Focus

The student will state assumptions held by Urey and Miller prior to the performance of their experiment.

Item

Harold Urey and Stanley Miller set up an experiment to test their hypothesis concerning the composition of the original atmosphere of the earth before biologically important molecules existed on the earth. They began their experiment with chemicals such as methane, water, carbon dioxide, and ammonia. These chemicals were placed in a reaction chamber and supplied with an energy source. List three assumptions with which they began their experiment.

Response/Marking Scheme

Explanations used in science today to explain phenomena can be used to explain phenomena in the past. 1

The composition of the early atmosphere consisted of the compounds which they used in their experiment. 1

Energy sources such as lightning and radioactivity were present on the early earth. 1

Possible: 3

Maximum: 3

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Protein Structure
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KhMC.03
GUIDELINE OBJECTIVE CODE: 11Kh 41Kg
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3.
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: amino acid protein

Guideline Objective

The student will be expected to describe, in general terms, the components of protein structure and the importance of this structure in the role of such biologically active proteins as enzymes and hormones.

Item Focus

The student should be able to identify the molecule that determines the sequence of amino acids in a protein.

Item

The precise sequence of amino acids in a protein is determined by

- [ ] A. a nucleotide sequence.
- [ ] B. its tertiary structure.
- [ ] C. the location of disulphide bridges.
- [ ] D. its secondary structure.
- [ ] E. the hydrogen bonds.

Response/Marking Scheme

Correct response: A

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Protein Structure
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KhMC.04
GUIDELINE OBJECTIVE CODE: 11Kh 41Kg
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: amino acid

Guideline Objective

The student will be expected to describe, in general terms, the components of protein structure and the importance of this structure in the role of such biologically active proteins as enzymes and hormones.

Item Focus

The student should be able to identify the structural cause of diversity in proteins.

Item

The great diversity of structure in proteins is mainly due to

- [ ] A. different kinds of bonds between successive amino acids.
- [ ] B. different numbers, kinds, and sequences of amino acids.
- [ ] C. the precise location of specific amino acids, common to all proteins.
- [ ] D. the action of the ribosomes.
- [ ] E. the disulphide and hydrogen bonds which determine molecular shape.

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Protein Structure
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B011KhMC.05
GUIDELINE OBJECTIVE CODE: 11Kh 41Kg
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.7, A.10, D.3
DIFFICULTY LEVEL: H
TIME ALLOCATION:

KEYWORDS: protein synthesis amino acid polypeptide

Guideline Objective

The student will be expected to describe, in general terms, the components of protein structure and the importance of this structure in the role of such biologically active proteins as enzymes and hormones.

Item Focus

The student should be able to apply knowledge of polypeptide structure to interpret experimental data.

Item

Refer to Figure 1K.36.

FIGURE 1K.36

GLU - GLU

CYS - CYS - ALA

ILEU - VAL

GLU - CYS - CYS - ALA

ILEU - VAL - GLU - GLU

ILEU - VAL - GLU

GLU - CYS

GLY - ILEU - VAL - GLU

VAL - GLU

Investigations by F. Sanger and others, were important in the earliest efforts to learn the primary sequences of amino acids in polypeptides. The polypeptide was hydrolyzed into small fragments by treatment with acid, and, in separate experiments, with protein-digesting enzymes. The resulting small fragments were analyzed by chemical means. The amino acid sequence was determined by trying to piece together small overlapping fragments to reverse the hydrolysis process. Do this with fragments in Figure 1K.36. The number of amino acids in the reconstructed polypeptide is

☐ A. 6

☐ B. 7

☐ C. 8

☐ D. 9

☐ E. 26

Response/Marking Scheme

Correct response: C

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Protein Structure
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KhMC.06
GUIDELINE OBJECTIVE CODE: 11Kh
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: protein amino acid

Guideline Objective

The student will be expected to describe, in general terms, the components of protein structure and the importance of this structure in the role of such biologically active proteins as enzymes and hormones.

Item Focus

The student should be able to recognize the factors responsible for the characteristics of protein.

Item

Four of the following properties potentially affect the characteristics of specific proteins. Which one does NOT account for differences between proteins?

- [ ] A. The kinds of amino acids.
- [ ] B. The sequence of amino acids.
- [ ] C. The number of amino acids.
- [ ] D. The number of ribosomes involved in their synthesis.
- [ ] E. The shape of the molecule.

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Protein Functioning
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KhMC.07
GUIDELINE OBJECTIVE CODE: 11Kh
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: enzyme lock and key model

Guideline Objective

The student will be expected to describe, in general terms, the components of protein structure and the importance of this structure in the role of such biologically active proteins as enzymes and hormones.

Item Focus

The student should be able to explain the lock and key model of enzyme action.

Item

In using the analogy of a key and a lock to explain enzyme action, some of the following form part of the model.

I The key is analogous to the enzyme and the lock to the substrate.
II The key is analogous to the substrate and the lock to the enzyme.
III The stem of the key is analogous to the protein part of an enzyme.
IV The stem of the key is analogous to the non-protein part of the enzyme.
V A key which will open only one lock is analogous to an enzyme which has a high degree of specificity.

Which of the above statements are correct?

☐ A. I, IV, and V

☐ B. II, III, and V

☐ C. I and III only

☐ D. II and IV only

☐ E. I, III, and V

Response/Marking Scheme

Correct response: E

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Biologically Important Molecules
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KhMC.09
GUIDELINE OBJECTIVE CODE: 11Kh
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: protein water

Guideline Objective

The student will be expected to describe, in general terms, the components of protein structure and the importance of this structure in the role of such biologically active proteins as enzymes and hormones.

Item Focus

The student should be able to identify the major components of organisms.

Item

Water is the most abundant substance in all organisms. Next to water, the major component of living cells is

- [ ] A. lipids.
- [ ] B. vitamins.
- [ ] C. carbohydrates.
- [ ] D. nucleotides.
- [ ] E. proteins.

Response/Marking Scheme

Correct response: E

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Biologically Important Molecules
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KhMC.10
GUIDELINE OBJECTIVE CODE: 11Kh
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.6, A.10
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: protein excretion nitrogenous wastes

Guideline Objective

The student will be expected to describe, in general terms, the components of protein structure and the importance of this structure in the role of such biologically active proteins as enzymes and hormones.

Item Focus

The student should be able to identify the molecule whose metabolism results in nitrogenous wastes.

Item

Nitrogenous wastes, if permitted to accumulate, can prove toxic to an organism. The organic compound whose metabolism yields nitrogenous wastes is

☐ A. a lipid.

☐ B. a vitamin.

☐ C. a carbohydrate.

☐ D. ATP.

☐ E. a protein.

Response/Marking Scheme

Correct response: E

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Biologically Important Molecules
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KhMC.11
GUIDELINE OBJECTIVE CODE: 11Kh
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: nitrogen protein

Guideline Objective

The student will be expected to describe, in general terms, the components of protein structure and the importance of this structure in the role of such biologically active proteins as enzymes and hormones.

Item Focus

The student should be able to identify the source of nitrogen for an animal.

Item

What is the source of most of the nitrogen in the body of an animal?

- [ ] A. urea
- [ ] B. proteins
- [ ] C. fats
- [ ] D. atmospheric nitrogen
- [ ] E. nitrates

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Protein Functioning
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KhMC.12
GUIDELINE OBJECTIVE CODE: 11Kh
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: protein

Guideline Objective

The student will be expected to describe in general terms the components of protein structure and the importance of this structure in the role of such biologically active proteins as enzymes and hormones.

Item Focus

The student should be able to identify the functions of proteins within a cell.

Item

All but one of the following are functions of proteins within a cell. Which one is NOT a function of proteins?

- [ ] A. providing structure
- [ ] B. switching genes on and off
- [ ] C. controlling osmosis
- [ ] D. catalyzing chemical change
- [ ] E. facilitating active transport

Response/Marking Scheme

Correct response: C

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Protein Functioning
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KhMC.13
GUIDELINE OBJECTIVE CODE: 11Kh
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: enzyme protein

Guideline Objective

The student will be expected to describe, in general terms, the components of protein structure and the importance of this structure in the role of such biologically active proteins as enzymes and hormones.

Item Focus

The student should be able to identify the aspects of enzyme functioning.

Item

Which of the following is NOT true about enzymes?

- [ ] A. They function best at a particular pH.
- [ ] B. Some enzymes require activators.
- [ ] C. They function best at specific temperatures but break down at high temperatures.
- [ ] D. They are essential to the metabolism of cells for the conversion of energy.
- [ ] E. They undergo a major chemical change after reacting with their specific substrate.

Response/Marking Scheme

Correct response: E

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Protein Functioning
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KhMC.14
GUIDELINE OBJECTIVE CODE: 11Kh
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: denaturation protein enzyme

Guideline Objective

The student will be expected to describe, in general terms, the components of protein structure and the importance of this structure in the role of such biologically active proteins as enzymes and hormones.

Item Focus

The student should be able to identify a statement that best describes the functioning of an enzyme.

Item

Which of the following statements about enzymes is most correct?

- [ ] A. All enzymes are catalysts.
- [ ] B. All catalysts are enzymes.
- [ ] C. Catalysts prevent chemical reactions.
- [ ] D. Denaturation of proteins always involves enzymes.
- [ ] E. A denatured enzyme is more specific in its action.

Response/Marking Scheme

Correct response: A

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Enzyme Activity
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B011KhMC.15
GUIDELINE OBJECTIVE CODE: 11Kh
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.5
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: enzyme catalase

Guideline Objective

The student will be expected to describe, in general terms, the components of protein structure and the importance of this structure in the role of such biologically active proteins as enzymes and hormones.

Item Focus

The student will be expected to identify the optimum temperature for the action of an enzyme.

Item

The enzyme catalase, which promotes the decomposition of hydrogen peroxide into water and oxygen, was extracted from fresh liver. The extract was then divided into 5 equal portions which were placed in water baths at a range of temperatures.

Students tested the activity of the enzyme by dropping small filter paper discs, soaked in hydrogen peroxide, into each extract solution. The activity of the catalase caused bubbles of oxygen to form on the discs, causing the discs to float to the surface. The more active the catalase, the faster the discs floated to the surface.

At which temperature would the activity of the enzyme be the greatest?

- [ ] A. 5°C
- [ ] B. 10°C
- [ ] C. 25°C
- [ ] D. 37°C
- [ ] E. 95°C

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Enzyme Activity
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B011KhMC.16
GUIDELINE OBJECTIVE CODE: 11Kh
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.5
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: enzyme catalase

Guideline Objective

The student will be expected to describe, in general terms, the components of protein structure and the importance of this structure in the role of such biologically active proteins as enzymes and hormones.

Item Focus

The student will be expected to predict the action of an enzyme.

Item

The enzyme catalase, which promotes the decomposition of hydrogen peroxide into water and oxygen, was extracted from fresh liver. The extract was then divided into 5 equal portions which were placed in water baths at a range of temperatures.

Students tested the activity of the enzyme by dropping small filter paper discs, soaked in hydrogen peroxide, into each extract solution. The activity of the catalase caused bubbles of oxygen to form on the discs, causing the discs to float to the surface. The more active the catalase, the faster the discs floated to the surface. At which temperature would the discs NOT rise?

☐ A. 5°C

☐ B. 10°C

☐ C. 25°C

☐ D. 37°C

☐ E. 95°C

Response/Marking Scheme

Correct response: E

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Enzyme Activity
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B011KhMC.17
GUIDELINE OBJECTIVE CODE: 11Kh
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.5
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: enzyme catalase

Guideline Objective

The student will be expected to describe, in general terms, the components of protein structure and the importance of this structure in the role of such biologically active proteins as enzymes and hormones.

Item Focus

The student will be expected to predict the action of an enzyme.

Item

The enzyme catalase, which promotes the decomposition of hydrogen peroxide into water and oxygen, was extracted from fresh liver. The extract was then divided into 5 equal portions which were placed in water baths at a range of temperatures.

Students tested the activity of the enzyme by dropping small filter paper discs, soaked in hydrogen peroxide, into each extract solution. The activity of the catalase caused bubbles of oxygen to form on the discs, causing the discs to float to the surface. The more active the catalase, the faster the discs floated to the surface. At which temperature would the discs rise most slowly?

☐ A. 5°C

☐ B. 10°C

☐ C. 25°C

☐ D. 37°C

☐ E. 95°C

Response/Marking Scheme

Correct response: A

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Protein Functioning
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KhMC.18
GUIDELINE OBJECTIVE CODE: 11Kh
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: enzyme activity pH denaturation

Guideline Objective

The student will be expected to describe, in general terms, the components of protein structure and the importance of this structure in the role of such biologically active proteins as enzymes and hormones.

Item Focus

The student should be able to relate changes in the environment of an enzyme to changes in its catalytic activity.

Item

A slight change in the pH of its surroundings changes the activity of an enzyme by

- [ ] A. altering its 3-dimensional shape.
- [ ] B. breaking its peptide bonds.
- [ ] C. increasing the activation energy of the reaction.
- [ ] D. masking its active site.
- [ ] E. causing it to precipitate.

Response/Marking Scheme

Correct response: A

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Protein Structure
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KhEE.01
GUIDELINE OBJECTIVE CODE: 11Kh
INSTRUMENT TYPE: EE
KLOPFER: A.1, A.2, A.3, A.9
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: enzyme protein catalyst

Guideline Objective

The student will be expected to describe, in general terms, the components of protein structure and the importance of this structure in the role of such biologically active proteins as enzymes and hormones.

Item Focus

The student should be able to explain the effect of heat and pH changes on the shape and activity of enzymes.

Item

Explain clearly how changes in the immediate environment of an enzyme molecule alter its effectiveness as a catalyst. Include two specific examples in your answer.

Response/Marking Scheme

The active site is a tiny portion of an enzyme responsible for catalysis,	1
It is made up of amino acid residues that are usually widely spaced in the primary sequence,	1
but are brought close together by the folding of the molecule (tertiary structure).	1
A change in shape alters the relationship of residues at the active site, changing or destroying the catalytic activity.	1
The shape of the enzyme is maintained mostly by weak bonds susceptible to environmental disturbance.	1
Any 2 examples, at 3 marks each	
E.g. "hydrophobic bonds"	1
are disturbed by cold	1
and become more stable as temperature increases.	1
E.g. "hydrophilic bonds"	1
are disturbed by changes in the chemical activity of water,	1
reflecting a change in the effective "concentration" of water molecules.	1
E.g. acid/base interactions are disturbed by changes in pH resulting in neutralization. E.g. ion bridges are disturbed by changes in ion concentrations altering the point of equilibrium.	
All of these, except hydrophobic, plus dipole/dipole interactions	1
are disrupted by heat,	1
because of increased vibration, stretching, and rotation of atoms weakening bonds.	1
Covalent (disulphide) bonds	1
are disrupted by mercury ions,	1
that react with sulphhydryl groups much more competitively than other sulphhydryl groups do.	1
Possible:	17
Maximum:	10

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Protein Functioning
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KhER.01
GUIDELINE OBJECTIVE CODE: 11Kh
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: enzyme

Guideline Objective

The student will be expected to describe, in general terms, the components of protein structure and the importance of this structure in the role of such biologically active proteins as enzymes and hormones.

Item Focus

The student should be able to define "enzyme"; account for the shape of enzymes; and explain the importance of shape in the functioning of enzymes.

Item

A. Define the term enzyme.

B. How do enzymes function?

C. How is the shape of an enzyme determined?

D. What is the significance of an enzyme's shape?

Response/Marking Scheme

A. An enzyme is a protein molecule 1

that acts as a catalyst. 1

B. Enzymes alter the rate of a chemical reaction 1

without being permanently changed by the reaction. 1

Most enzymes speed up the rates of chemical reactions
by lowering the activation energy of the reaction. 1

An enzyme is specific in its action, catalyzing only one or a very few reactions. 1

The reactants upon which an enzyme acts are substrates. 1

C. Most proteins have a tertiary structure, and it is the folded nature of this structure
that determines the shape of the enzyme. 1

The folded nature of an enzyme is determined by
the sequence of amino acids in the protein chain, 1

and the interaction of the 'R' groups in different parts of the chain. 1

Bonds that maintain the tertiary structure include
disulphide bonds and hydrogen bonds. 2

Hydrogen bonds result from the simultaneous attraction of a hydrogen nucleus to
groups of atoms on two separate amino acid residues. 2

The attraction is caused by a partial positive charge on the hydrogen nucleus and
a partial negative charge on the other group of atoms. 1

D. An enzyme aligns with its substrate by a very precise molecular matching.
Thus the shape of an enzyme is critical to its functioning. 1

Possible: 16

Maximum: 12

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Protein Structure
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B011KhER.02
GUIDELINE OBJECTIVE CODE: 11Kh
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, D.3
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: enzyme hydrogen bond helix

Guideline Objective

The students will be expected to describe, in general terms, the components of protein structure and the importance of this structure in the role of such biologically active proteins as enzymes and hormones.

Item Focus

The student should be able to account for the shape of enzymes in terms of hydrogen bonding and sulphur bridges.

Item

Describe how bonds between atoms assist in giving a protein its unique three-dimensional shape. Labelled diagrams may be used to complement your answer.

Response/Marking Scheme

The secondary structure of a protein is a helical configuration.	1
The helical folds are brought about chiefly	1
through the attraction of R-terminal	1
oxygen and hydrogen atoms, which form	1
hydrogen bonds throughout the helix.	1

Any of the above marks may be given for a diagram of secondary structure.

In the tertiary structure of a protein,	1
the alpha helix is, in turn, coiled and folded	3
into the unique shape for that specific protein.	1
This is due to the interaction among neighbouring amino acids.	1
One such interaction is the sulphhydryl bridges	1
formed between cysteine amino acids.	1
The bridges are actually covalent bonds.	1
Hydrogen bonds, van der Waals forces, and	2
electrostatic attraction are also involved.	1
The shape of globular proteins, including	1
the biologically active enzymes, are	1
determined by these forces.	

Any of the above marks may be given for a diagram of the tertiary structure.

Possible: 20

Maximum: 15

Quality: 3

Total: 18

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 01
UNIT NAME: CHEMICAL BASIS OF LIFE

TOPIC: Protein Structure
CURRICULAR EMPHASIS: Nature of Science
KEYWORDS: amino acid

INSTRUMENT CODE: B011KhER.03
GUIDELINE OBJECTIVE CODE: 11Kh
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, B.1, C.2
DIFFICULTY LEVEL: M
TIME ALLOCATION:

Guideline Objective

The student will be expected to describe, in general terms, the components of protein structure and the importance of this structure in the role of such biologically active proteins as enzymes and hormones.

Item Focus

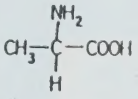
The student should be able to account for properties of proteins in terms of the structure of particular amino acids.

Item

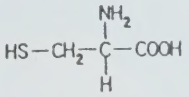
Fibrous proteins, such as those that fill spaces between cells (e.g., collagen, elastin) contain unusually large amounts of the amino acids alanine, valine, leucine, and isoleucine in their molecules.

Refer to Figure 1K.37.

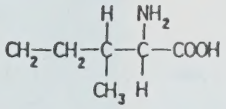
AMINO ACIDS: STRUCTURAL FORMULAE



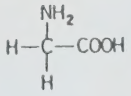
Alanine



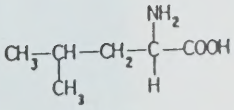
Cysteine



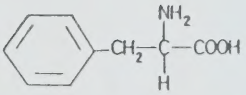
Isoleucine



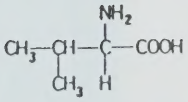
Glycine



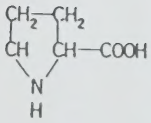
Leucine



Phenylalanine



Valine



Proline

Using the structural formulae of the amino acids shown in Figure 1K.37, explain why these particular amino acids make up so much of fibrous proteins.

Response/Marking Scheme

The four amino acids named all have hydrocarbon side chains,	1
and would therefore tend to be non-polar (hydrophobic)	1
and would cling to molecules of their own kind	1
rather than be carried off in suspension in body fluids.	1
Thus they remain in place between the cells, binding cells together.	1
Possible:	5
Maximum:	4

Teacher Notes

Min Gu OAC biology. Unit I
574.076 Chemical basis
0713
059bi
Unit I

Min Gu OAC biology. Unit I
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